The teacher as designer of competency-based education

The Teacher as Designer
of Competency-Based Education

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Chapter 1

Introduction

During the past decade, teaching concepts in the field of higher education have been in a state of transition. The dominance of the 'knowledge-transmission' paradigm has decreased in favor of new paradigms, such as 'process-oriented' teaching and 'competency-based education' (CBE). This transition has triggered curriculum reforms in many institutes for higher education. Unfortunately, the development of learning materials for CBE, providing authentic learning experiences in a domain of competence, hasn't kept pace with these reforms. Consequently, teachers involved in curriculum development for CBE are expected to adopt new roles, such as 'coach of learning processes' and 'instructional designer'. Higher-education inspection reports make clear that this adoption process confronts many teachers with problems, and obstructs innovation processes (HBO-Raad, 1997). However, there is no clear picture of the exact causes and possible solutions to the problems teachers experience. This thesis attempts to explore the nature, the causes, and possible solutions of the instructional design problems that higher-education teachers have to face as a result of the recent curricular changes. This introductory Chapter starts with an exploration of these problems and a description of instructional design theories, models, and methods that can be applied by higher-education teachers to design learning tasks for CBE. Then, the research questions and an overview of the associated experiments are presented. The research described in this thesis starts with a detailed analysis of the teachers' design approach and its relation to instructional design approaches for CBE. Then, a study is presented in which it was investigated if a web-based training in an instructional systems design (ISD) approach can compensate for the deficiencies that were identified in the teachers' intuitive instructional design approach. The question whether such an ISD approach can best be applied by individual teachers or in small teams of teachers, is answered in the next study. In order to optimize the training of teachers, the last, explorative experiment compares the conventional training of an ISD approach with product-oriented worked examples to an alternative approach focusing on process-oriented worked examples.

Exploration of the problem

The evolution in higher education during the last decade can be characterized by two important and interrelated traits. The first is the teacher's perception of education as the facilitation of learning processes (Samuelowicz, 2001). The teacher's most important role has changed from transmitter of knowledge to coach of the student's learning processes. This concept of teaching is also called 'process-oriented teaching' (Vermunt and Verloop, 1999), or 'new learning' (Simons, van der Linden, and Duffy, 2000). The second trait of the evolution is the shift to competency-based education (Tillema, Kessels, and Meijers, 2000; Foster, 2001). This shift has originated from the growing demand for competent employees in professional domains (Levesque, Lauen, Teitelbaum, Librera, and MPR Associates, Inc., 2000). Not so long ago, it was considered normal that competence was acquired as a function of job experience (Kolb, 1984). Novices could only become competent professionals after a few years of job experience. Currently, educational institutes are expected to deliver competent professionals. Consequently, CBE should be directed at providing students with the knowledge, skills, and attitudes that enable them to recognize and solve problems in their domain of study or future work, i.e., authentic tasks (Keen, 1992). Although many educational institutes display themselves with a competency-based educational concept, on the level of concrete educational programs and practices this philosophy does not materialize. This may be caused by the holistic character of CBE, which confronts teachers with the very complex instructional design task of integrating theory and practice through problem solving in real world contexts and tasks (Foster, 2001; Mulcahy, 2000). Indeed, inspection reports of Dutch institutes for higher education (HBO-Raad, 1997) show that higher-education teachers experience problems in translating competency-oriented curriculum principles into concrete learning materials.

Although several obstacles to the realization of CBE can be identified, this thesis focuses on the micro level of the teachers and assumes that the main problem underlying the teachers' inability to design CBE can be described as an instructional design problem. It is clear that certain characteristics at the meso level, such as the inadequate fit of the current school organization, and decisions of the government at the macro level, can hinder or facilitate the realization of curricula for CBE. For instance, in the Netherlands the teachers' legal status as employees is discipline-bound (cf. Cohen, 1996; de Weert, 2001) and in most institutes of higher education there is no reward for the application of principles that are prerequisite for CBE and that break with discipline boundaries.

The shift from knowledge-based to competency-based education forces teachers to change their way of thinking and working. The traditional knowledge-based curriculum was not very demanding with regard to the design of instruction in the form of learning tasks. The learning materials only contained piecemeal practices that consisting of isolated knowledge and skills that make up the whole task. Instead, in the new competency-based curriculum, teachers have to think holistically in terms of the whole authentic task that competent professionals perform. According to recent insights from instructional design theories (Van Merriënboer and Kirschner, 2001), learning tasks should consist of meaningful whole task experiences with integrated knowledge and skills. In order to design such learning tasks in practice, the teachers should be able to analyze the principles and strategies that are used by experts to solve the typical types of problems in a certain domain. Then, the teachers have to create a series of problem situations, which will require the students to apply these principles and strategies in order to become competent. According to Spector (2001), teachers are expected to comprehend their complex domain as one unified *system*.

Domain expertise is not taught in the same way as in knowledge-oriented education. Competencies are organized hierarchically, which means that sub skills of a particular skill can be seen as conditional for skills or that sub skills may relate to other sub skills as subsequent or simultaneous (Van Merriënboer, Clark, and de Croock, 2002). In most of the present curricula however, knowledge is organized as an accumulation of knowledge structures and subsequent application. In CBE, the resulting competence is considered to be more than the sum of its sub skills: it is an integrated complex skill, which may account for teacher's problems in programming CBE. This way of integrated thinking adds a lot of complexity to the design task of teachers. Teachers, more or less, have to be able to show the same level of integrative thinking as experts in the field. According to the Cognitive Load theory (Sweller, 1988; see for an overview also Sweller, van Merriënboer, and Paas, 1998), such highly integrative tasks are very complex and may impose a very high load on the teachers' cognitive system.

From the viewpoint of Cognitive Load theory, two roads can be taken to increase the chance that the ideas of CBE can be transformed by teachers into concrete learning tasks. First, according to Cognitive Load theory, the successfulness of the instructional design for CBE depends to a large extent on the cognitive support provided by an appropriate instructional design method. In the light of the complexity and the integrative demands of the task, an Instructional Systems Design (ISD) approach seems a promising candidate. A second potential solution can be found in collaborative design. The holistic and integrative way of thinking that is required to design CBE forces teachers to look over the borders of the subject that they are used to teach in the knowledge-oriented curriculum. In practice stimulating teachers to work collaboratively on the design task can promote this process. In terms of cognitive load, the proposed interdisciplinary collaboration can increase the available cognitive capacity, and consequently relatively decrease the cognitive load.

Although, several publications can be found on how teachers plan and organize lessons (Shavelson, 1983; Clark and Lampert, 1986; Clark and

Yinger, 1987; Reiser, 1994), a clear-cut answer to the question whether teachers apply instructional design methodology during the design of learning tasks for CBE cannot be found in the literature. Unfortunately, the available publications on teacher thinking originated from the paradigm of education as 'knowledge-transmission' and, consequently, cannot be directly applied to a methodology for creating authentic, whole learning tasks for a certain competence. Therefore, in this thesis the perspective of recent instructional systems design (ISD) theories and models with a focus on the world of work (van Merriënboer and Kirschner, 2001) will be used to explore the contribution of ISD approaches to the solution of the teachers' design problem. Klauer (1997) and Moallem (1998) have shown that teachers do not frequently apply ISD models. They explain this from the viewpoint that teachers do not like prescriptive methods and that teachers generally work from their personal perceptions about the influence of the curriculum on their lessons.

Although in practice, teachers in the new curriculum are responsible for the design of learning tasks for CBE, the question can be raised what makes the efforts described in this thesis to support the teachers' design of CBE, worthwhile? Why not leave the design task to instructional design experts? First, as Reigeluth (1983) acknowledges, curriculum and instruction cannot be separated. The importance of the teacher as a stakeholder/participant of the design process for the quality of the learning materials is emphasized in instructional-design theories (Reigeluth and Nelson, 1997; Visscher-Voerman, 1999). Furthermore, by leaving the design of CBE to instructional design experts, the teachers' role would be limited to that of coach and assessor of learning processes that are evoked from materials that others have invented. This would devaluate the job of a teacher and the social appreciation for the job (Seddon, 1997). Also, this type of top-down curriculum development is not considered a successful strategy for curriculum development (Lang, Bünder, Kysilka, Tillema, and Smith, 1999; Foster, 2001).

To determine how teachers can be supported in their struggle to design learning tasks for CBE, it is important to explore what instructional design methods they actually use in their current daily practice. Also, it is necessary to find a suitable ISD method that can be used for the design of CBE, can be mastered by the teachers, and is acceptable to them. In the next section the search for an appropriate instructional design methodology is described.

Instructional design theories and models for design of authentic and realistic learning tasks for competency-based education

In formulating search criteria for an appropriate instructional design methodology for CBE, a first one is that application of the methodology must be suitable for the teacher to teach the student the *whole complex task*. Instead of isolated elements of knowledge and practice, an *integrated approach* is needed in which whole tasks are used throughout the practice phase. A second search criterion is that applying the methodology results in *authentic learning tasks* (Clark and Estes, 1999). These are tasks of the type the experts encounter in their daily practice. Both the first and second criterion follow from the fact that higher education is expected to deliver students who are able to function as novice practitioners, and who have acquired a basic repertoire of professional problem solving strategies and techniques. A third criterion is the appropriateness of the methodology for building a *competency-based curriculum*. In this type of curriculum the focus is not on the single elements of knowledge and skills but on the integrated competence in a domain. It is not a sum-of-the-parts curriculum but a hierarchical network of sub competencies. A fourth criterion is that the model or methodology must account for a *learning-process orientation*. After a series of learning tasks the student must be able to display the skills or competence. Not every student needs the same exercise and coaching. Coaching of the student's problem solving trials includes challenging students to solve problems and giving positive feedback during task performance (Vermunt and Verloop, 1999). A fifth criterion is *transfer*. The student must be able to solve new problems, that is, problems that differ from the ones trained on. According to Cognitive Load theory, this means that the methodology should take the human cognitive architecture into account and focus practice on the processes of schema construction and schema automation. Finally as a sixth criterion, the methodology should be acceptable to the teachers. In practice, this means that it should not be too prescriptive, that is, forcing teachers to follow a linear approach instead of allowing them to apply their own highly contextual, socially based reflections on instruction (Moallem, 1998).

Some of these criteria can be recognized in the principles, which Merrill (2002) distinguishes as generic in instructional models, without regard of their basic assumptions or educational philosophies. These 'First Principles of Instruction' include that instruction is problem-based, activates prior knowledge and skills, demonstrates skills and application of knowledge and skills, and integrates skills in realistic tasks. Merrill refers to Instructional Design theories and models, as examples to illustrate the presence of one of more of these principles. According to Merrill, the Four Component Instructional Design (4C-ID) model (Van Merriënboer, 1997) "is perhaps the most comprehensive recent model of instructional design that is problem centered and involves all of phases of instruction identified in this paper." (p. 56). Next it will be argued that Instructional Systems Design approaches and in particular the 4C-ID model of Van Merriënboer (1997) are compatible to these principles.

Furthermore Instructional Systems Design approaches seem to fit especially to the criterion of appropriateness for building an integrated, competency-based curriculum. Systems approaches enable 'systemic thinking' and approach education as a programmable or designable, unified whole. Systems approaches are based upon the comprehension of complex unified systems that are built up of constituent parts (Spector, 2001). Spector refers to the discipline of System Dynamics (Forrester, 1961) and considers the interest from the field of education for case-based learning, situated learning and project-based learning as instances of holistic system thinking. Complex systems consist of components that outside of the context of the system do not have meaning. Complex systems may be effectively modeled by using relatively simple representational schemas. System approaches (ISD-methods) are particularly suited for solving design problems at the curriculum level, because a complex skill or competence can, following Spector's reasoning, be seen as a hierarchically organized complex system, of which the constituent components are to be acquired or learned in relation to each other. Instead of an accumulation of disciplinary organized knowledge this results in a holistic design approach for education, (Banathy, 1991; Klauer, 1997; Reigeluth and Avers, 1997). This advantage of ISD-approaches must be balanced against the often discussed and negatively criticized prescriptive character of ISD models, which could limit the autonomy of teachers. However, recent ISD methods increasingly focus on stakeholder participation in the design process. Teachers and students are seen as the most important stakeholders in solving instructional design problems (Visscher-Voerman, 1999). In contrast to classical ISD approaches, modern ISD-approaches enable teachers to *preview* the consequences of the design

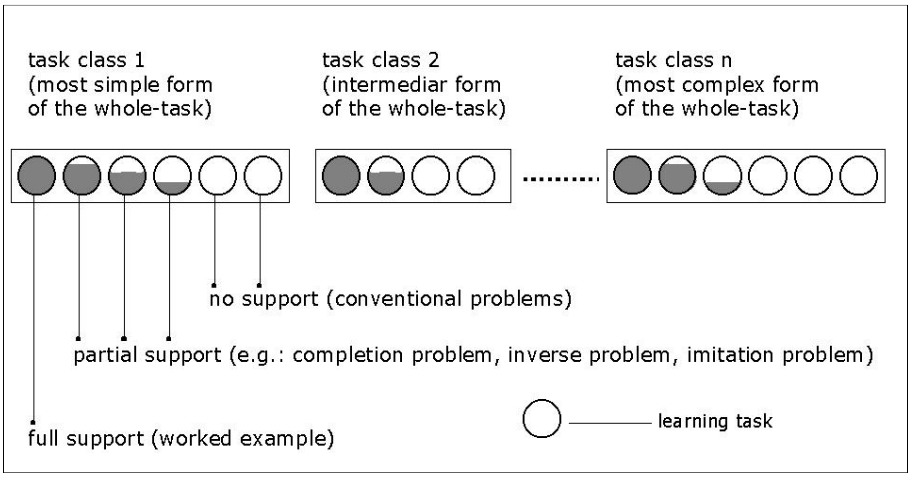

Figure 1 Decreasing support of learning tasks in task classes following the 4C-ID model. Adapted from Van Merriënboer, Clark and de Croock, 2002.

for their daily practice in an early stage of the design process (Reigeluth and Nelson, 1997).

The critique of being prescriptive applies to the linearity of the classical five phased ISD approach, which consists of the phases of Analysis, Design, Development, Implementation and Evaluation or abbreviated as ADDIE (Wedman and Tessmer, 1993). Tennyson (1997) has suggested an ISD model that views instructional design not as a linear but as a 'nonlinear system that dynamically adapts to the problem conditions of a given situation and that enables the designer frequently to switch between phases of design' (p. 414). According to Clark and Estes (1999) the 4C-ID model is one of the few instructional design models that are learning-process oriented.

It is assumed in this thesis that the 4C-ID model (van Merriënboer, 1997) is at this moment the only instructional systems design model that fits all the six criteria mentioned and is also consistent with Merrill's (2002) generic Five Principles of Instruction. The 4C-ID model is developed for the design of learning tasks for complex cognitive skills. In terms of this model learning tasks are viewed as concrete, authentic and meaningful whole-task experiences, which help the learner to construct cognitive schemas for the solution of complex tasks and problems (van Merriënboer and de Croock, 2002).

In this model task complexity is controlled by Task Classes. These are series of learning tasks with the same task-complexity. By defining series of task classes from the simplest form of authentic whole-task performance to the most complex form, the instructional designer can regulate the level of complexity. Within one and the same task class the learner support decreases from highly supported to independent task performance (see *Figure 1,* in which the decreasing support is represented by the shading in the circles). Decreasing or fading support is realized by the use of different problem formats, such as worked examples (i.e., full support), completion tasks (i.e., partial support), and conventional problems (i.e., no support).

In the 4C-ID model the relation between competence (complex cognitive skill), task complexity, and learning tasks is analyzed in a hierarchical skill analysis, which in most cases forms the first step of the design process. In this analysis the complex skill or competence is decomposed into constituent skills. Lower level skills are prerequisite to higher-level skills.

Skills on the same level in the hierarchy may be displayed simultaneously or sequenced (see *Figure 2* for an example of the hierarchy for the competence of 'searching literature').

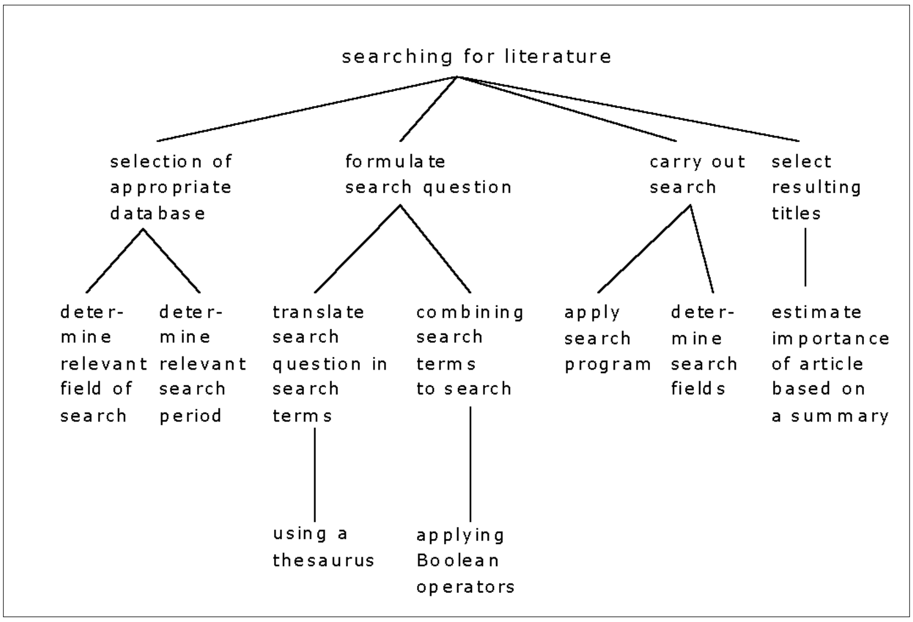

Figure 2 Hierarchical skill analysis for the complex skill of 'searching for literature'. Adapted from Van Merriënboer, Clark and de Croock, 2002.

The learning tasks form one of the four components of the model. The other components comprise the analysis of complex skills as recurrent or non-recurrent, providing appropriate support for tasks classes (heuristics or *supportive info*) or for learning tasks (rules, or *just-in-time info* and *part-task training* to automate sub skills). The methodology comprises ten steps, which the order is not prescribed, and which enables a typical zigzag design (van Merriënboer and de Croock, 2002). Macro level sequencing enables the designer to generate blueprints for training with this model. To conlcude about the criteria, the model seems appropriate to build an integrated, competency-based curriculum on the basis of whole authentic learning tasks. The model has a clear learning-process orientation and aims at transfer of the acquired competencies in new situations. Finally the model is not characterized by a linear prescriptive approach but by a flexible dynamic design methodology. The model was awarded (Zemke, 2001) and has been successfully applied in practice of highly technical training.

To meet the increasing call of teachers for a suitable methodology for CBE, a transcription in the Dutch language was made (Janssen-Noordman and van Merriënboer, 2002). Altogether this instructional systems design model seems to be a suitable and promising model for the design of CBE.

Research questions and experiments: An overview

The first question investigated in this thesis is how teachers, who are involved in developing learning tasks for CBE proceed, what problems they experience with their intuitive design approach, and what is the nature of these problems. In Chapter 2, these questions are addressed in an exploratory study with ten higher-education teachers. Using a Repertory Grid technique, the participants are requested to describe and categorize all subsequent activities undertaken during design of study units. The descriptions of activities and categories collected are compared to the type of activities and design phases of an instructional design made with a typical ISD approach. In this exploration it is also checked to what extent the teachers display new roles like coach and facilitator of learning processes.

The second research question of this thesis is whether a web-based training in an instructional systems design methodology, such as the 4C-ID method, can compensate for the deficiencies identified in the first, exploratory study, and may help higher-education teachers to design better study units for CBE as compared to study units designed in their own, intuitive, experience-based way. Chapter 3 reports about this experiment. With thirty-six higher-education teachers it was investigated if a web-based training in an instructional systems design (ISD) approach can compensate

for the design deficiencies that were identified in Chapter 2 and leads to better design results.
A third important research question in this thesis is whether an ISD-method, such as the 4C-ID method can better be applied in a team setting than individually. The importance of this question lies in the integrative character of CBE and the breaking out of disciplinary boundaries, that CBE brings with it. This question is investigated in an experiment, reported in Chapter 4. After training in the 4C-ID method, forty-two higher-education teachers have to apply the method to design tasks, either individually or in a small team of colleagues.
Finally in Chapter 5 reports about an explorative study with twenty-four higher-education teachers, in which the conventional training with emphasis on product-oriented worked examples is compared to an alternative training approach with emphasis on process-oriented worked examples.
Chapter 6 recapitulates the results and conclusions from the four studies, presents overall conclusions and discussion, and formulates recommendations for future research. The thesis is concluded with summaries in English and in Dutch.

References

Banathy, B. H. (1991). *Systems design of education: A journey to create the future*. Englewood Cliffs, NJ: Educational Technology Publications.

Clark, C. M., & Lampert, M. (1986). The study of teacher thinking: implications for teacher education. *Journal of Teacher Education, 37,* 27-31.

Clark, C. M., & Yinger, R. J. (1987). Teacher planning. In G. Calderhead (Ed.), *Exploring teacher's thinking*. London: Cassell.

Clark, R. E., & Estes, F. (1999). The development of authentic educational technologies. *Educational Technology, 39,* 5-16.

Cohen, M. J. (1996). Human resource management in universiteiten. *Tijdschrift voor Management en Organisatie, 5,* 499-510.

De Weert, E. (2001). Pressures and prospects facing the academic professsion in the Netherlands. *Higher Education, 47*(1-2), 77-101.

Forrester, J. W. (1961). *Industrial Dynamics*. Cambridge, MA.: MIT Press.

Foster, S. (2001). Pragmatic, problem solving approaches to curriculum and assessment policy. *Journal of Educational Policy, 16,* 53-66.

HBO-Raad. [Association of Universities of Professional Education] (1996). *Koers gekozen. Eindrapport van de vervolgvisitatiecommissie lerarenopleidingen basisonderwijs.* [Course determined. Final follow-up inspection report of Primary Teacher Training Colleges] Den Haag, The Netherlands: Voorlichtingsdienst HBO-Raad.

Janssen-Noordman, A. M. B., & van Merriënboer, J. J. G. (2002). *Innovatief onderwijs ontwerpen. Via leertaken naar complexe vaardigheden.* [Designing innovative education: from learning tasks to complex skills]. Groningen, The Netherlands: Wolters-Noordhoff.

Keen, K. (1992). Competence: What is it and how can it be developed? In J. Lowyck, P. De Potter & J. Elen (Eds.), *Instructional Design: Implementation issues* (pp. 111-122). Brussels: IBM International Education Center.

Klauer, K. J. (1997). Instructional design theory: A field in the making. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Series Eds.) *Instructional design: International perspectives, Volume 1.* (pp. 447-455). Mahwah, N J: London.

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice Hall.

Lang, M., Bünder, W., Hansen, H., Kysilka, M.L., Tillema, H., & Smith, K. (1999), Teacher professional development in the context of curriculum reform. In M. Lang, Olson, J. Hansen, H. and Bünder, W. Changing schools/Changing practices: *Recent research on teacher professionalism.* Louvain: Garant.

Levesque, K., Lauen, D., Teitelbaum, P. A. M., Librera, S., & MPR Associates. (2000). *Vocational education in the United States: Toward the year 2000* (Report No. 029). Washington D.C.: U.S. Department of Education. Office of Educational Research and Improvement.

Merrill, M.D. (2002). First principles of instruction. *Educational Technology, Research and Development, 50*(3), 43-59.

Moallem, M. (1998). An expert teacher’s thinking and teaching and instructional design models and principles: An ethnographic study. *Educational Technology, 46*(2), 37-64.

Mulcahy, D. (2000). Body matters in vocational education: the case of the competently trained. *International Journal of Lifelong Education, 19,* 506-524.

Reigeluth, C. M., & Avers, D. (1997). Educational technologies, chameleons and systemic thinking. In R. M. Branch, B. B. Minor, & D. P. Ely (Eds.), *Educational media and technology yearbook*: *Vol. 22*. (pp. 132-137). Englewood, Colorado: Libraries Unlimited, Inc.

Reigeluth, C. M., & Nelson, L. M. (1997). A new paradigm of ISD? In R. M. Branch, B. B. Minor, & D. P. Ely (Eds.), *Educational media and technology yearbook*: *Vol. 22*. (pp. 24-35). Englewood, Colorado: Libraries Unlimited, Inc.

Reiser, R. A. (1994). Examining the planning practices of teachers: Reflections on three years of research. *Education and Technology, 43,* 25-34.

Samuelowicz, K. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41,* 299-325.

Seddon, T. (1997). Education: deprofessionalized? Or reregulated, reorganized and reauthorized? *Australian Journal of Education, 41,* 228-246.

Shavelson, R. J. (1983). Review of research on teachers' pedagogical judgments, plans, and decisions. *The Elementary School Journal, 83,* 392-413.

Simons, P. R. J., Linden, J. L. van der, & Duffy, T. (Eds.). (2000). *New learning*. Dordrecht, The Netherlands: Kluwer Academic Press.

Spector, M. J. (2001). Philosophical implications for the design of instruction. *Instructional Science, 29,* 381-403.

Sweller, J. (1988). Cognitive load during problem solving. Effects on learning. *Cognitive Science, 12,* 257-285.

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10,* 251-295.

Tennyson, R. D. (1997). A system dynamics approach to instructional systems development. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design: international perspectives*: *Volume 1: Theory, research and Models*. (pp. 413-427). Mahwah, NJ: Lawrence Erlbaum Associates.

Tillema, H. H., Kessels, J. W. M., & Meijers, F. (2000). Competencies as building blocks for integrating assessment with instruction in vocational education: a case from the Netherlands. *Assessment & Evaluation in Higher Education, 25,* 265-278.

Van Merriënboer, J. J. G. (1997). *Training Complex Cognitive Skills: A Four Component Instructional Design Model for Technical Training.* Englewood Cliffs, N.J.: Educational Technology Publications.

Van Merrienboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: the 4C-ID model. *Educational Technology Research and Development, 50,* 50-64.

Van Merriënboer, J. J. G., & de Croock, M. B. M. (2002). Performance-based ISD: 10 steps to complex learning. *Performance Improvement, 41,* 33-39.

Van Merriënboer, J. J. G., & Kirschner, P. A. (2001). Three worlds of instructional design: state of the art and future directions. *Instructional Science, 29,* 429-441.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9,* 257-280.

Visscher-Voerman, J. I. A. (1999). *Design approaches in training and education: a reconstructive study*. Doctoral Dissertation, University of Twente, Enschede, The Netherlands.

Wedman, J., & Tessmer, M. (1993) Instructional designers' decisions and priorities: A survey of design practice. *Performance Improvement Quarterly 6*(2), 43-57.

Zemke, R. (2000). Jeroen van Merriënboer, Quiet revolutionist. *Training, 37,* 44.

Chapter 2

Exploring teachers' instructional design practices from a systems design perspective [1]

Curricular changes in higher vocational education have rendered teachers' instructional design activities increasingly important. Using a repertory grid technique, this paper sets out to analyze current design activities of ten teacher trainers. Their actual approach is compared with an Instructional Systems Design (ISD) approach and related to innovative teacher roles. Teachers' activities show an imbalance in two ID phases, that is problem analysis and evaluation. The results suggest that they attempt to translate curricular goals directly into concrete lessons and they pay relatively little attention to evaluation. In line with this finding, they underrate the two innovative teacher roles of the 'diagnostician' and the 'evaluator'. It is argued that imbalanced or incomplete design approaches and perceived roles may hinder innovation in education. Implications for the support of teachers' design activities are discussed.

Dutch teacher training colleges have been shown to be successful in changing the framework of their curriculum, but to experience problems in translating the desired changes into new learning practices (HBO-Raad, 1996). Desired changes in the curriculum can be related to the more general paradigm changes in society and organizations, such as the transition from the 'Industrial Age' into the 'Information Age' (Kerr, 1996; Reigeluth and Nelson, 1997). In the Age of Information students will have to take more and more responsibility for their own learning processes, which are initiated and controlled by realistic, job-oriented or competency-oriented learning tasks. These changes are referred to as the 'new learning' (Simons et al., 2000). The implementation of this type of curricular change into new

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learning practices will affect teachers' role perceptions. Teachers will have to change their role from being 'transmitters of content' to becoming 'coaches of students' learning processes' (Pratt et al., 1998; Vermunt and Verloop, 1999). From this viewpoint, teacher trainers' problems of curriculum innovation can be interpreted as problems of instructional design (Enkenberg, 2001). In addition, the increasing emphasis on real life problem solving tasks requires teachers to develop complex design skills. Teachers' participation in the curriculum redesign process is considered to be a crucial factor in the success of curriculum innovation (Beijaard, 1994; Lang et al., 1999).

We assume that the acquisition of expertise in instructional design can help teachers to translate the abstract new curriculum framework into concrete new learning tasks. This translation process requires teachers to widen their scope from the lesson level to the level of curriculum development in their college. Systems approaches to instructional design are believed in particular to provide help in solving teachers' problems of translating new curriculum principles into concrete learning tasks. Systems approaches namely, treat the design of lessons, as parts of the curriculum, holistically within the total curriculum as a 'system' (Reigeluth and Avers, 1997). Indeed, Klauer (1997) has argued that the application of an ISD method could broaden teachers' design repertoire.

However, teachers seldom apply ISD methods. Moallem (1998) has argued that this might be because systems approaches do not correspond with the nature of the personal theories, which teachers construct by reflecting on their instruction. Klauer (1997) has identified the 'prescriptive' character of ISD methods as a possible reason. Finally, Reigeluth and Nelson (1997) and Visscher-Voerman (1999) argue that classical ISD designs offer little opportunity to teachers, as important stakeholders of design, to 'preview' in an early stage the effects of design. Unlike the negative criticism of some radical constructivists on the value of ISD approaches for teachers, in this paper we take a neutral stance to explore that value (see also Spector, 1995).

The purpose of this exploratory study was to obtain more insight into teachers' actual design practices. To elucidate the extent to which this

practice corresponds to the main phases of a general ISD approach, we first compare the design practices reported by the teachers with a widely accepted model for instructional design (Leshin et al., 1992). In addition, we examine the extent to which teachers recognize themselves in, attach importance to, and experience a training need for new teacher roles that support process-oriented learning. Finally, teachers are invited to compare their own design approach with an ISD approach, that is especially suitable for the design of realistic, competency based learning tasks, which are required for curriculum innovation. The Four Component Instructional Design model of Van Merriënboer (1997) meets this criterion.
Three instruments have been developed to investigate the teacher trainers' design approaches: the 'Knowledge Elicitation Interview', the 'Role Grid Scale', and the 'ISD Comparison Scale'. These instruments were developed on the basis of the 'Repertory Grid Technique' (Kelly, 1955; see also Fransella and Bannister, 1977; Herman, 1996; Pope and Keen, 1981; Munby, 1982). The Knowledge Elicitation Interview is used to describe and elucidate the teacher's implicit practical knowledge. The teacher trainers report in detail all activities they normally perform while developing a new study unit. Each activity is considered as an element of the personal constructs representing the teacher's design approach. Constructs can be made explicit by having the teacher trainer sort the reported design activities into categories, to which names are attributed.
To construct the Role Grid Scale, we adopt six teaching roles described by Vermunt and Verloop (1999). According to Vermunt and Verloop, process-oriented teaching and learning promote self-regulated knowledge construction. This implies a series of new roles in which teachers have to learn to achieve process-oriented learning. These roles are quite different from the roles teachers play in the knowledge transmission model of teaching. In process-oriented learning the main tasks of the teacher are to initiate, support, and influence the thinking processes of students in their learning process. The associated roles are: (a) diagnostician, (b) challenger, (c) model learner, (d) activator, (e) monitor, and (f) evaluator. We hold that these roles and the concept of process-oriented learning are good instances

of the desired teacher perspectives for 'the new learning'. Following the Repertory Grid Technique, these roles are represented as elements of three given constructs: (a) the recognition, (b) the importance and (c) the training need in the role. The differences of teacher trainers' ratings between recognition, importance and training need may be interpreted as an indication of a teacher's position on a continuum between the knowledge transmission model and a model of process-oriented teaching and learning.

The ISD Comparison Scale is constructed by specifying design activities and design phases that ISD experts normally use to develop units of study. The design activities are based on the Four Component Instructional Design (4C-ID) model of Van Merriënboer (1997). This model focuses on a detailed analysis of complex cognitive skills to be trained. A training design for the type of skills requires a task hierarchy, decisions about types of tasks, sequencing of tasks, and supportive knowledge. The teacher trainers rate the difference of each of the specified design activities in the worked out ISD approach with their own approach.
We conclude the introduction to this study with a final remark about the relationship between learning process-oriented teaching roles and the design approaches of the participant teacher trainers. Process-oriented teaching and learning, as cited by Vermunt and Verloop (1999), or 'new learning' (Simons et al., 2000), require not only new coaching roles for the teacher, but also the role of 'designer' of (authentic) learning tasks that initiate, facilitate, or stimulate students' learning actions. The 4C-ID model (Van Merriënboer, 1997) has been characterized as a learning process centered design approach (Clark and Estes, 1999). A comparison of differences of an expert ISD approach with the approach of the participants may, therefore, be considered to reflect their effort to realize new curriculum or teaching concepts.

Methods and Materials

Participants
In two typical teacher-training colleges in the Netherlands, the Hogeschool

Maastricht and the Hogeschool Limburg, ten instructor-
teachers (5 men and 5 women) were selected for participation. Within their college, all participants were involved in the design process of new study units for various subject areas.

Materials

There were five instruments for collecting the data. The General Interview was used to collect general data such as the teachers' experience with developing units of study, their general experience as teacher trainers, their subject area, the importance of innovation in daily practice, and the time required to develop units of study.

The Knowledge Elicitation Interview was used to elicit the teachers' design experience. Here an adapted Rep(ertory) Grid Technique was applied (Munby, 1982), in which the teacher trainers were invited to describe for instance to a new colleague the way they normally approach the design of a study unit. Each design activity that was reported represented an 'element' in the terminology of the Rep Grid Technique. These elements had to be categorized by the participants using their own criteria, yielding their personal 'constructs' (Herman, 1996) of their design approach. The strength of each element in relation to the construct was to be measured on a nine-point scale, where 1 indicates a very weak relation and 9 a very strong relation to the construct (Pope and Keen, 1981; Gaines and Shaw, 1993).

The Role-Grid Scale was used to collect data on the significance of innovative teaching Roles for the participants. The instrument consists of three constructs and six elements. The 'constructs' are (a) *recognition* of each of the six roles in current teaching practice, (b) perceived *importance* of each of these roles for innovation processes in the teacher training college, and (c) perceived *training need* in each of these six roles.

The constructs were measured on a nine-point categorical scale. For the construct 'recognition' the scale extremes were defined as follows: rating 1 means: 'you hardly recognize or do not recognize this role; it doesn't belong to your repertoire of roles', and rating 9 means: 'you fully recognize this role, it really belongs to your repertoire of roles'. For the construct 'importance' the scale extreme 1 was defined as: 'you think this role is not at all important for your profession' and scale extreme 9 as: 'you think this role is really important for your profession'. For the construct 'urgency for training' scale extreme 1 was defined as: 'you do not think training in mastering this role is at all urgent for you', and scale extreme 9 as: 'you think training in mastering this role is extremely urgent for you'. The six 'elements' correspond to the six teacher roles, which were defined as follows: a) the diagnostician: as a teacher you are skilled in recognizing the learning styles and the problem solving strategies of your students; (b) challenger: as a teacher you are skilled in challenging your students to try new learning and thinking strategies; (c) model learner: as a teacher you are able to demonstrate the learning and thinking strategies that are characteristic for the domain you are specialized in. In this way, you elucidate and facilitate knowledge construction principles and the application of knowledge in your domain; (d) activator: once your students have a clear idea of learning strategies and their application, you encourage your students to re-use these strategies; (e) monitor: as a teacher you coach and monitor the learning processes of your students. Once they perform at a basic level and are able to perform the task autonomously, they may consult you in case of problems; (f) evaluator: in process-oriented learning you assess the quality of your students' use of thinking strategies.

The ISD Comparison Scale was used to compare an ISD approach to developing units of study with the respondent's own approach. This instrument consisted of a given grid with one construct and 29 elements. The construct pertains to the 'degree of similarity' between a given approach and the participants' own approach. The participants had to compare 29 elements of the given instructional design approach (based on the 4C-ID-model of Van Merriënboer, 1997) with their own approach, using again a 9-point categorical scale with verbal labels ranging from 'low similarity' to 'high similarity'.
The nine-point scale was printed in very large fonts and on a large sheet of paper. This scale had to be used in all of the three instruments (the Knowledge Elicitation Interview, the Role Grid Scale, and the ISD

Comparison Scale), by putting the printed definition of the extremes of each variable ('construct') at both ends of the scale. An audiocassette recorder with a microphone was used to record the respondents' spoken reactions. The score of each respondent's (numbered) element and construct during the interview session was registered in an Excel Spreadsheet on a laptop computer. Further interview materials consisted of a set of white lined system cards that enabled the participants to note the element names and a set of yellow 'post-it' labels to write the construct names on. Printed instructions were developed for the Knowledge Elicitation Interview, the Role Grid and ISD Comparison Scale to read or present to the participants.

Procedures

Each instrument contained a printed protocol with clear instructions and examples showing the respondents how to answer and categorize. A checklist for the interviewer was provided. All interviews and scores were taped on an audiocassette recorder. During the interviews, notes were taken down. The grid scores of the Knowledge Elicitation Interview, the Role Grid Scale and the ISD Comparison Scale were typed immediately during the interview into prepared tables on a laptop computer. The elements elicited in the Knowledge Elicitation Interview had to be noted by the respondents on system cards, one catchword per card per idea, while the spoken examples were recorded on audiocassette and noted on paper. The cards had to be sorted by the respondents and the sorting category names (i.e. the construct names) had to be specified in catchwords on the post-its. The examples had to be recorded and noted. In the Role Grid Scale the experimenter was reading the task from the protocol and the respondents were given both the construct and role descriptions on paper. They were asked to score the constructs and role descriptions on the nine-point scale. The ISD Comparison Scale used an identical procedure. The Debriefing Interview questions were read from the protocol and the answers were noted by the experimenter and recorded on tape.

Results

General Interview

On average, participants had 13 years of experience as a teacher trainer. Most of them also had experience in various other jobs in teacher education, secondary education or primary education. The following subject areas were reported: instructional science, music, and social studies/ philosophy of life, art education, and calligraphy/writing skills. The design experience expressed as the average cumulative number of new units of study was 4 units. Most of the respondents revised their units of study every year. With regard to the final responsibility for the design of units of study, 6 respondents shared this with colleagues and 4 respondents were individually responsible. Eight respondents also taught the study unit they had designed, while two of them did not. The design of a complete new study unit took on average about 40 hours of work. The respondents reported the following activities of curriculum innovation in their teacher training colleges: (a) acquiring new teaching techniques and methods, (b) development of methods of self-responsible learning, (c) being more of a coach than a transmitter of knowledge, (d) shifting from theory to practice, (e) solving assessment problems, and (f) developing a professional attitude within their students.

Knowledge Elicitation Interview

The ten teachers generated between 8 and 15 design activities (elements) and between 3 and 5 constructs to categorize these elements. In total 118 elements and 41 constructs were reported. The design elements were compared with a prototypical model of instructional design of Leshin et al. (1992). The following numbered elements of the seven sub-classifications of this model were used by two experts to categorize all design activities reported by the teachers: 1 = analyze the problem, 2 = analyze domains, 3 = analyze and sequence tasks, 4 = analyze and sequence supporting content, 5 = specify learning events and activities, 6 = perform interactive message design, 7 = evaluate instruction. (Leshin et al., 1992). This categorization of the design activities (i.e., elements) resulted in an absolute frequency distribution according to the seven design steps of the model of Leshin et al. (1992), which is presented in *Figure 1*. The number of respondents generating the elements of each design is indicated in Figure 1.

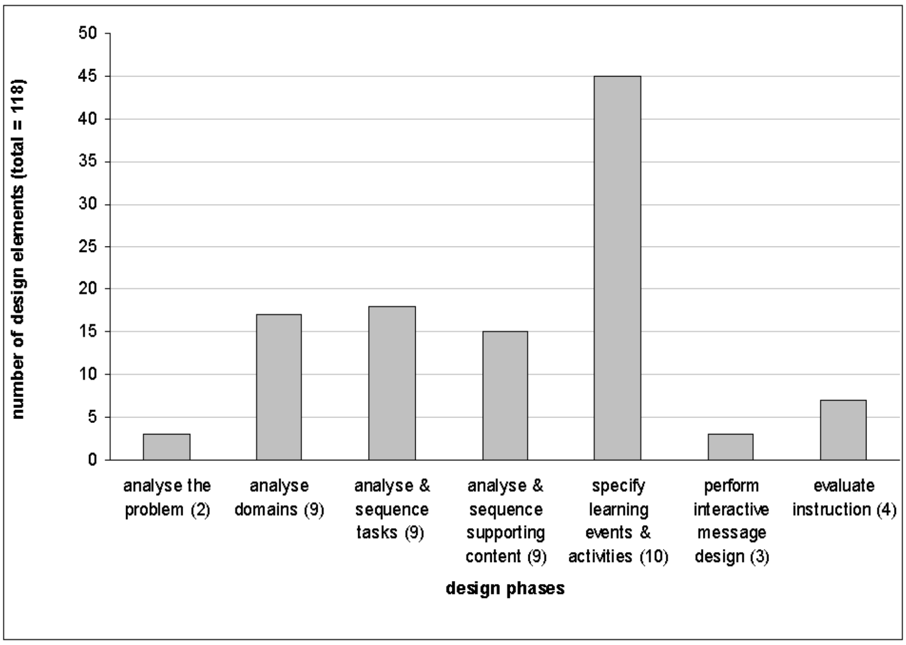

Figure 1. *Absolute frequencies of reported design activities, sorted in categories of the model of Leshin et al. (1992). Note that the number of the teachers that generated these elements is given between parentheses.*

The frequency distribution shows the absolute frequencies of activities concerning problem analysis (category 1), interactive message design (category 6) and evaluation of the implemented design (category 7) that is 3, 3, and 7 respectively. To determine whether these values differed from the model, we assumed that the activities reported by the teachers would be equally distributed across the seven design categories of the model. This resulted in a mean expected frequency of 17 for each of the seven categories.

A Chi-square one-sample test (Siegel, 1956) showed that the observed frequencies differed significantly from the expected mean frequency ($\chi^2 = 75.25$; $df = 6$; $p < 0.001$). Binomial tests (Siegel, 1956) performed to determine the locus of this difference revealed significant differences for the categories relating to problem analysis, specify learning events and activities, perform interactive message design, and evaluation of the implemented design (respectively, $N = 20$, $x = 3$, $p < 0.001$; $N = 62$, $x = 45$, $p < 0.001$; $N = 20$, $x = 3$, $p < 0.001$; $N = 24$, $x = 7$, $p < 0.032$). The other categories relating to analyzing domains, analyzing and sequencing tasks, and analyzing and sequencing supporting content were not significantly different from the expected mean (respectively, $N = 34$, $x = 17$, $p > 0.1$; $N = 35$, $x = 18$, $p > 0.1$; $N = 32$, $x = 15$, $p > 0.1$).
The constructs that were generated by the teachers were sorted by the experts to the following four main categories of the model: 1 = analysis of needs; 2 = selecting and sequencing of content; 3 = developing lessons; 4 = evaluating the instruction. (Leshin et al., 1992). The constructs showed a wide range of individual differences. To reduce their number, the constructs were categorized along the four main design phases of the Leshin Model. The resulting absolute frequency distribution per category of the classified constructs is shown in *Figure 2*.

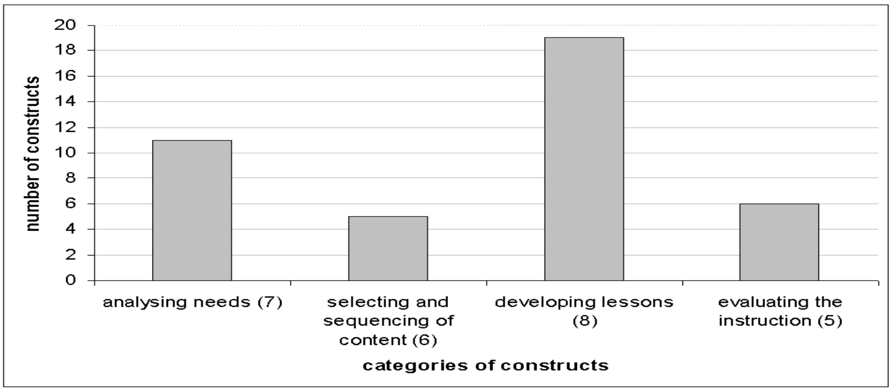

Figure 2. *Absolute frequencies of reported design constructs, sorted in main categories of the model of Leshin et al. (1992). Note that the number of the teachers that generated these elements is given between parentheses*

This distribution of constructs looks similar to that of the distribution of elements and, therefore, is analyzed in the same way. The absolute frequencies of the categories were significantly different from the expected mean frequency of 10 ($\chi^2 = 10.5$; $df = 3$; $p < 0.02$). Further Binomial tests of the difference of each category from the expected mean frequency of 10 showed no significant differences (analyzing needs: $N = 21$, $x = 10$, $p > 0.1$; selecting and sequencing content: $N = 15$, $x = 5$, $p > 0.1$; developing lessons: $N = 29$, $x = 10$, $p > 0.1$; evaluating instruction: $N = 16$, $x = 6$, $p > 0.1$).

Role Grid Scale

Each teacher generated three series of six role scores on the nine-point scale. These series of six scores corresponded to one of the constructs: recognition, importance, or training need. The mean scores of all participants on each role were calculated for each construct. The differences in ranking of the mean scores of roles between the three series are displayed in *Table 1*.

Table 1 *Ranking of mean scores of roles on the constructs 'recognition', 'importance', and 'training need'*

rank	*recognition*	*importance*	*training need*
1	monitor (7.7)	model-learner (8.1)	evaluator (7.0)
2	model-learner (7.4)	monitor (8.1)	diagnostician (6.3)
3	challenger (6.9)	challenger (8.0)	monitor (5.9)
4	activator (6.5)	activator (7.6)	activator (5.0)
5	diagnostician (5.3)	diagnostician (7.5)	challenger (5.0)
6	evaluator (5.1)	evaluator (7.1)	model-learner (4.4)

Note. Ranking ranged from 1 (highest mean score) to 6 (lowest mean score).

In the case of ties, the roles were ranked alphabetically. The ranks ranged from 1 for the highest mean score to 6 for the lowest mean score. With regard to the constructs recognition and importance, the roles of diagnostician and evaluator were ranked lowest. However, for the construct ‘training need’ these roles were ranked highest. Conversely, the roles of the challenger and the model-learner were ranked highest for the constructs ‘recognition’ and ‘importance’, and lowest for the construct ‘training need’.

ISD Comparison Scale

The frequency distribution of the raw scores was negatively skewed, with a standard error of skewness of 0.68. Skewness applied to all variables, except for the design activities of determination of recurrent skills and criteria for feedback on performance. For each design element, we calculated the mean value of the scores across all subjects. *Table 2* on page 34 and 35 shows the mean scores per design element.

In the table the design elements are categorized in the design phases of the worked-out approach. The Grand Mean of all the design-element scores is 6.7 on the nine-point scale. The value nine was specified as having a strong resemblance to the participant’s own design approach, while the value one indicated a marked deviation from that approach. A Wilcoxon Signed Ranks test on the difference between the mean scores below and above the Grand Mean revealed a significant difference ($Z = -3.06$; $p < .002$).

Discussion and Conclusions

A small-scale exploratory study was conducted among ten teacher trainers. The general intention was to obtain more insight into the way teacher trainers design their units of study in daily practice. Due to curriculum changes in Dutch Teacher Training Colleges, we expected shifts in perceived teacher activities from *lesson-like* towards more *designer-like* activities, and in perceived teacher roles from *transmitter of knowledge* to *coach of learning processes*. Using the Knowledge Elicitation Interview, elements and constructs of ten teacher-trainers’ design practices were

elicited. The elements and constructs were scored as categories and main categories of a prototypical ISD model (Leshin et al., 1992).
The Role Grid Scale enabled more insight to be gained into the way that these teachers perceive new teaching roles, which are believed to be required for the innovation of education. In addition, the ISD comparison scale was used to obtain information on the discrepancy between elements of the Four Component Instructional Design model (Van Merriënboer, 1997) and the elements in the teachers' actual design approach.
The Knowledge Elicitation Interview revealed substantial differences in frequencies of design elements and constructs. High absolute frequencies were observed for elements that had been categorized in the design phase 'specifying learning events'. Low absolute frequencies were found in the design phases of 'problem analysis', 'interactive message design', and 'evaluation of instruction'. Differences between these frequencies and the expected mean frequency were significant. The analysis of the frequency distributions of the constructs reveals a similar pattern. We suggest two possible explanations for this observation. One is that the approach of these teacher trainers to developing learning tasks and study units is based upon a traditional knowledge transmission concept, and primarily consists of existing routines in determining content and selecting well-known learning tasks and teaching strategies. This might account for the problems that teacher trainers' experience in translating new curriculum principles of competency-based and process-oriented learning into concrete lessons.

Another possible explanation is that the teacher trainer's approach to developing learning tasks or study units may not even be considered as an (instructional) design-approach. According to Visscher-Voerman (1999), an instructional design is expected to incorporate the typical phasing of the so-called ADDIE model (Rosset, 1987; Wedman and Tessmer, 1993). ADDIE stands for: Analysis, Design, Development, Implementation, and Evaluation. From the perspective of the ADDIE model, it can be argued that the teachers do not follow a complete design cycle in their design approach, because they pay little attention to the phases of Analysis and Evaluation. This suggests that training in a complete instructional design methodology might be most helpful to teachers. Although Klauer (1997) and Moallem (1998) have speculated about possible causes, it remains unclear why teachers do not frequently use an ISD approach for preparing their study units.

Table 2 Mean scores on ISD omparison scale.

Design phase and design activity	**Mean**
Analysis phase: Exploration of problem	
acceptance of task to design a study unit	6.0
estimation of available time for design task	6.1
determine position of study unit in curriculum	6.6
importance of study unit for the student	8.1
check if there is existing information or experience	7.1
exploring the value system around this study unit	5.5
difficulty of the educational problem	6.2
estimate of successful solution of the problem	5.8
Analysis phase: Analysis of the problem	
global diagnosis of skills	7.2
sequencing of sub skills	6.4
sequencing of learning processes	6.1
determination of prior knowledge	7.4
determination if skills are recurrent or new	5.0
analyze, determine and sequence supporting knowledge	6.8

Design phase and design activity	Mean
Design of learning tasks	
define exercises per skill	6.6
define criteria for feedback on performance	7.0
timing and format of supportive knowledge	6.1
define criteria for achievement of objectives	7.8
define an appropriate learning environment	7.3
planning of exercises and practice in time	7.2
Learning materials production phase	
elaborate instruction	8.1
produce supportive knowledge	7.9
preparation of practice	6.7
worked out monitoring and tutoring plan	6.2
worked out evaluation plan (for collection of evaluation data)	5.4
Implementation of design phase	
collection of data for process evaluation	6.8
collection of data for product evaluation	6.5
Evaluation phase	
evaluation of design: educational problem solved?	7.5
evaluation of the process	7.0

Note. Activieties with mean scores below 6.7 are in italics.

Analysis of the Role Grid findings resulted in the observation of changes in ratings of the six teacher roles between the three constructs recognition, importance, and training need. The roles 'diagnostician' and 'evaluator' keep the same lowest-two ranks for the constructs recognition and importance and change to the first two ranks in the construct 'training need'. This is an almost complete inversion of the ranking order. At the same time we see a comparable inversion of the block of the first four ranks of roles (monitor, model-learner, challenger and activator). Finally, what is remarkable is that the 'activator' role keeps the same rank in all three constructs. A possible interpretation of this effect is that for increasingly recognized roles, which are also seen as important for innovation, there is a decrease in the training need and vice versa. This effect seems quite logical: what you already do, needs no further training. But the observation that this effect exactly applies to the 'diagnostician' and 'evaluator' roles seems to be highly compatible with the trend observed in the results of the Knowledge Elicitation Interview: low levels of analysis and evaluation during the design of a study unit. The inversion effect seems to affect the 'activator' role to a lesser extent, possibly because this is a difficult role that combines different roles, such as diagnosing existing student strategies and stimulating their re-use. Although these effects are difficult to test in this study, a replication with the Role Grid Scale in follow-up research with 36 participants (Hoogveld et al., 2001), confirms these effects.
The results of the ISD Comparison Scale can be interpreted as follows. Most design-elements with mean scores under the Grand Mean fall within the Analysis Phase of design. Further, two important design elements refer to the phase of Evaluation. These elements are a worked-out evaluation plan (for collecting evaluation data) and the collection of data for product evaluation, both of which must be carried out in phases of design, preceding the actual phase of evaluation. Two scores, the definition of exercises per skill and the timing and format of supportive knowledge are design elements that are typical for the learning process orientation of the model used (Van Merriënboer's 4C-ID model). Low scores for the worked-out monitoring and tutoring plan in the development or learning materials production phase, preceding the phase in which monitoring and tutoring

actually occur, could be an indication that teachers directly execute monitoring and tutoring without designing it beforehand.

To summarize, the present results consistently indicate that the cause for the low correspondence of the model approach with the teacher’s own approach is located at the analysis and evaluation activities. The Knowledge Elicitation Interview as well as the ISD Comparison Scale shows that the teacher trainers seem frequently to omit or neglect the phases of problem analysis and evaluation in instructional design. In addition, this effect is compatible with the low *recognition* ranking of the diagnostician and evaluator roles, found in the Role Grid.

We can only speculate as to the possible causes of these phenomena. One explanation is the lack of experience in the application of design methods, which is also indicated by Klauer (1997). Another possible explanation might be the increasing complexity of the design of study units, for instance in analyzing complex skills and finding appropriate learning tasks for practicing those skills. This type of complex design activities indeed requires a sound ISD approach, instead of the use of teaching routines. The results of the Role Grid Scale and the General Interview show that the teacher trainers are in transition from a knowledge transmission-oriented teaching concept towards more process-oriented teaching concepts. Teachers should therefore develop a design attitude and learn design skills to solve their problems related to curriculum innovation.

In future research we hope to gain more insight into teachers' potential for educational design and developing a designer's attitude. The relatively low values for the recognition of the diagnostician and evaluator roles, but relatively high values for the training need in these roles, suggest some optimism for further research. In presenting the effects and trends, we realize that our conclusions are based on a small sample of participants and colleges. However, the results of a recent study of Hoogveld et al. (2001), which used more participants and confirms the claims made in this study, add strength to our conclusions and emphasize the importance of further research in this field.

References

Beijaard, D. (1994). Teacher competence, every day teaching practice and professionalization. *European Journal of Agricultural Educational and Extension, 1,* 65-80.

Clark, R. E.,& and Estes, F. (1999). The development of authentic educational technologies. *Educational Technology, 39*, 5-16.

Enkenberg, J. (2001). Instructional design and emerging teaching models in higher education. *Computers in Human Behavior 17*, 495-506.

Fransella, F., & Bannister, D. (1977). *A manual for Repertory Grid technique*. London: Academic Press.

Gaines, B. R., & Shaw, M. L. G. (1993). Basing knowledge acquisition tools in personal construct psychology. *Knowledge Engineering Review, 8*, 49-85.

HBO-Raad. [Association of Universities of Professional Education] (1996). *Koers gekozen. Eindrapport van de vervolgvisitatiecommissie lerarenopleidingen basisonderwijs.* [Course determined. Final follow-up inspection report of Primary Teacher Training Colleges] (Sectorale kwaliteitszorg hbo, nr 28 en 33). Den Haag, the Netherlands: Voorlichtingsdienst HBO-Raad.

Herman, R. L. (1996). The repertory grid technique: path to teacher description or teacher potential? *Instructional Science 24*, 439-459.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merriënboer, J. J. G. (2001). The effects of a web-based training in an instructional systems design approach on teachers' instructional design behavior. *Computers in Human Behavior 17*, 363-371.

Kelly, G. A. (1955). *The psychology of personal constructs*. (Vols 1-2). New York: Norton.

Kerr, S. T. (1996). Visions of sugarplums: The future of technology, education and the schools. In S.T. Kerr (Ed.), *Ninety-fifth yearbook of the National Society for the Study of Education: Part II. Technology and the future of schooling* (pp. 1-27). Chicago: National Society for the Study of Education.

Klauer, K. J. (1997). Instructional design theory: A field in the making. In R.D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design: International perspectives, Volume 1.* (pp. 447-455). Mahwah, N J: London.

Lang, M., Bünder, W., Hansen, H., Kysilka, M. L., Tillema, H., & Smith, K. (1999), Teacher professional development in the context of curriculum reform. In M. Lang, J. Olson, H. Hansen, and W. Bünder (Eds.), *Changing schools/Changing practices: Recent research on Teacher professionalism*, Louvain, Belgium: Garant.

Leshin, C. B., Pollock, J., & Reigeluth, C. M. (1992). *Instructional design strategies and tactics*. Englewood Cliffs, NJ: Educational Technology Publications.

Moallem, M. (1998). An expert teacher's thinking and teaching and instructional design models and principles: an ethnographic study. *Educational Technology Research and Development, 46*(2), 37-64.

Munby, H. (1982). The place of teacher's belief in research on teacher thinking and decision making, and an alternative methodology. *Instructional Science*, *11*, 201-225.

Olson, J. (1981). Teacher influence in the classroom: a context for understanding curriculum translation. *Instructional Science, 10*, 259-275.

Pope, M. L., & Keen, T. R. (1981). *Personal construct psychology and education*. London: Academic Press.

Pratt, D. D. and Associates. (1998). *Five perspectives on teaching in adult and higher education.* Malbar, Florida: Krieger publishing company.

Reigeluth, C. M., & Avers, D. (1997). Educational technologists, chamelions, and systemic thinking. In R. M. Branch and B. B. Minor (Eds.), *Educational media and technology yearbook*: *Vol 22.* (pp. 132-137). Englewood Cliffs, NJ: Educational Technology Publications.

Reigeluth, C. M., & Nelson, L. M. (1997). A new paradigm of ISD? In R. M. Branch and B. B. Minor (Eds.), *Educational media and technology yearbook*: *Vol 22*. (pp. 24-35). Englewood Cliffs, NJ: Educational Technology Publications.

Rosset, A. (1987). *Training needs assessment*. Englewood Cliffs, NJ: Educational Technology Publications.

Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences.* Tokyo: McGraw-Hill Kogakusha, LTD.

Simons, P. R. J., Linden, J. L. van der, & Duffy, T. (Eds.). (2000). *New learning.* Dordrecht: Kluwer Academic Press.

Spector, J. M. (1995). Integrating and humanizing the process of automating instructional design. In R. D. Tennyson, & A. Barron (Eds.)., *Automating instructional design: Computer-based development and delivery tool* (pp. 523-546). Brussels, Belgium: Springer-Verlag.

Van Merriënboer, J. J. G. (1997), *Training complex cognitive skills: A four-component instructional design model for technical training.* Englewood Cliffs, NJ: Educational Technology Publications.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9,* 257-280.

Visscher-Voerman, J. (1999). *Design approaches in training and education: a reconstructive study.* Doctoral Dissertation, University of Twente, Enschede, The Netherlands.

Wedman, J., & Tessmer, M. (1993). Instructional designers' decisions and priorities: A survey of design practice. *Performance Improvement Quarterly*, *6*, 43-57.

Chapter 3

The effects of a web-based training in an Instructional Systems Design approach on teachers' instructional design behavior[1]

Deficiencies in instructional design skill have been identified as a possible cause for the problems teachers of Dutch Polytechnics experience in designing competency-based education. This research investigates the effects of an Instructional Systems Design (ISD) training on teachers' instructional design behavior. Thirty-six teachers from 16 Dutch Teacher Training Colleges received 20 hours of web-based training either in an ISD based condition or in an experience-based design condition (EXP). In the ISD condition teachers were trained to apply the 4C-ID model of van Merriënboer (1997), in the EXP condition the teachers were trained to optimise their own approach. The results supported the hypotheses, indicating that the ISD-based training resulted in a higher quality of design and was evaluated more positive than the EXP approach. These findings suggest that training in an ISD approach can effectively support teachers' instructional design strategies.

Teachers of Dutch Polytechnics are reported experiencing problems in translating newly stated curriculum principles into concrete study-units (HBO-Raad, 1996). In a recent study, Hoogveld, Paas, Jochems, and Van Merriënboer (2001) identified deficiencies in the teacher's instructional design skills as a possible cause for these problems. The recently revised curricula of most Dutch Polytechnics rely heavily upon 'learning-process oriented' educational principles, such as thematic project-based education, case-based learning, problem-based learning and competency-based

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learning. Also, the interest of these institutions of higher education in distributing education over the web has increased greatly with the rapid growth and technical development of the Internet. The design approach of the teachers, however, did not experience a concomitant change accordingly and is still mainly based on the teaching principle of 'knowledge transmission' (Vermunt and Verloop, 1999). The new learning-process oriented teaching principles, preferably applied in a web-based environment, require an instructional design approach, which enables the teachers to program learning activities through which complex professional skills can be mastered (Reigeluth and Nelson, 1997). Hoogveld et al. (2001) argue that teacher's conventional experienced-based design approach, focusing on elaboration and structuring of domain content, is not effective in that respect. According to Tennyson (2001), competency in ISD methodology can be considered as one of the three basic core knowledge areas that need to be mastered by teachers to be able to apply learning-process oriented teaching principles in Internet based learning environments.

This study is based on the assumption that Instructional Systems Design (ISD) approaches can effectively support the teachers in the design of learning tasks for their students in the new curriculum. This hypothesis is based on the holistic character of the ISD approach. This means that it emphasizes the whole problem-solving cycle: Analysis, Design, Development, Implementation and Evaluation. Also, the scope of design of the ISD approach is not only formed by the content, and content structure, but also by the structure of the entire curriculum as a 'system'. Klauer (1997) and Moallem (1998) have shown that teachers are not well acquainted with ISD approaches and, consequently, do not frequently use them in the design of study units. The exploratory study of Hoogveld et al. (2002) showed that teachers' conventional design approach particularly shows serious gaps in the cycle's phases of Analysis and Evaluation (see also Rowland, 1992). In choosing an ISD model that can be used to prepare the teachers for their design task in the new curriculum, the acceptance of such a model by the teachers is a crucial element. Teachers do not like very prescriptive design methods, because they are trained to evaluate all preparation for lessons or study units in terms of successes in classroom interaction. This is part of their personal theories or beliefs (Moallem, 1998). As stakeholders of curriculum design processes, teachers always want to be able to directly 'preview' the consequences of decisions to prepare instruction. For this reason the ISD procedures applied, should be shorter than the classical ADDIE procedures and prototype these consequences permanently (Reigeluth and Nelson, 1997). Finally, when used by teachers, training in the ISD approach should not only cover macro-curriculum levels, but should also support micro-curriculum designs (Klauer, 1997). Applying these criteria, classical ISD models like the Dick and Carey (1996) model, the Romiszowski (1981) model, the Gagné and Briggs (1974) model, or the Leshin, Pollock and Reigeluth (1992) model, seem less appropriate to base the total ISD training upon.

In this study, Van Merriënboer’s (1997) Four-Component Instructional Design Model (4C-ID model) was chosen as an appropriate ISD approach. This model is considered one of the few ISD models that are learning-process oriented (Clark and Estes, 1999). In addition, the model takes a middle position between prescriptive empirical and descriptive analytical approaches, enables micro-level design, and gives the designer insight and control of the consequences of the design process. The model focuses on the programming of concrete learning tasks in cases or task classes in such a way, that the skills can be acquired in the context of the ‘whole’ professional task. As such, it can be considered as supportive for developing competency-based education (Vermunt and Verloop, 1999). Van Merriënboer's work on the 4C-ID approach was judged by the magazine *Training* as an 'incomparable way to dissect complex skills and create efficient learning designs’ (Zemke, 2000).

Relating this to the previously mentioned acceptance problems, the deficiencies in teachers’ instructional design skill can be eliminated by a training in the 4C-ID methodology since this methodology is relatively short and non prescriptive, and because it focuses on the factors underlying the deficiencies, namely, inadequate analysis and diagnosis.

The research question of this study is stated as follows: Can training in an ISD approach improve teachers' instructional design behavior? It is hypothesized that teachers, who are trained in an ISD-design approach, will show superior design skills as compared to teachers who were trained to optimize their conventional, experience-based, approach. It is also hypothesized that after the training, the ISD-trained teachers will show a more positive attitude towards this method as an effective support in skill-based instructional design than teachers trained to optimize their conventional design approach have towards that method. To investigate these assumptions, both the process and the product of design are studied.

Method

Participants
Participants were 36 instructors (27 men and 9 women) from 16 Dutch Primary Teacher Training Colleges. These colleges are charged with the training of future elementary or primary school teachers.

Materials and procedures
The two levels of the independent variable Instructional Design Training were ISD training condition and EXP training condition. The training in the ISD condition was based on the Four-Component Instructional Design model of van Merriënboer (1997). In the EXP condition the participants received training to optimize their own experience-based instructional design approach.
Before the start of the training the participants received a Preliminary Measurement Scale, a questionnaire that they had to fill in and return. The participants were randomly assigned to the two conditions. Within each condition two groups of 9 persons were created. During a condition-specific kick-off meeting, the participants were briefed about general aspects of the experiment and about aspects that were specific to their training condition. With regard to the training websites, arrangements were made to ensure that each participant only had admission to the condition-specific training web. This was controlled by admission to closed

websites of the Open Universiteit Nederland' learning environment 'Studienet'. The participants received a web-based training of 20 hours. Both the ISD and the EXP condition consisted of four one-week training blocks equally divided across the following subjects: 1) Introduction, 2) Evaluation of design problems with study units, recently made by the participants, 3) Design approach for creating learning tasks for new study units, and 4) How to integrate the just learned approach in the curriculum of participants' institution.

Both training conditions were set up as a task-guided individual study on the Internet, and comprised four to six different tasks per training block. Each task consisted of worked-out problem cases and offered opportunities to practice with design problems. Individual feedback, help, and coaching were provided in the websites e-mail facility during the exercises. Two expert tutors were available to provide feedback, help, and coaching to the participants during the training period of the experiment. Each tutor took care of one ISD group and one EXP group. Before the experiment a tutoring protocol was developed and both tutors were trained to use the protocol. Immediately after the training period, all participants received the same design task as an assignment. The design task required the participants to make a complete global design for a study unit that should be usable in their educational program. The participants had one month to complete the design assignment. For both conditions, instructions and design output-tools were available on a design-support web on the Internet. From this web, the participant could always get admission to all of the information of the training website, (s)he had admission to. All participants who finished the experiment were given a certificate and a small gift. In addition. The best design in each condition was rewarded with a book.

The condition-specific aspects for the ISD and EXP conditions are as follows: In the ISD condition Block 2 dealt with the function of evaluation in an ISD design approach and contained exercises to plan, work out and evaluate implemented designs. In the EXP condition Block 2 consisted of reflection on problems with recently constructed and implemented study units and of exercising sound evaluation principles. In the ISD condition,

Block 3 focused on the design of learning tasks, following van Merriënboer's 'whole-task approach' (van Merriënboer, 1997) and resulted in a blueprint of a series of lessons or study unit. Block 3 in the EXP condition consisted of working out learning tasks, based on a clear description of the learning objectives, a clear explication of instructional strategies, and of defining the concrete output of the learning tasks. Much attention was given to the optimizing of the coherence between these three activities by reflection. Block 4 in the ISD condition focused on 'macro-level sequencing', that is the application of the 4C-ID approach on the curriculum level. In the EXP condition Block 4 consisted of the reflection on the curriculum process.
To get more insight in the process character of the design tasks a one-day follow-up session was organized for two participants of each condition. They were randomly chosen from the participants who had finished the design assignment. During this session the retention of the characteristics of the approach that was trained was determined, before and after a short retraining of the approach. This retraining was followed by two experimental design tasks of about 90 minutes in duration. The participants were also asked about the re-use of the approach before and after retraining and after completing the experimental tasks. The screen-input activities on the computer during the design activity were videotaped and coded in categories, corresponding the main elements of the design approach.

Measures
Data were collected by means of a Preliminary Inquiry, the Evaluation of Approach Scale, the Expert's Assessment Scale, the Retention Test and the Videotaped design session. The Preliminary Inquiry served to collect three types of data: 1) general information (i.e., age, experience as teacher trainer, frequency of design of study tasks, and domain of design); 2) teacher's attitude towards solving instructional design problems, measured with a 20 item, 5-point Likert scale; 3) teacher's recognition of, and attached importance to teaching concepts and roles that support process-oriented

learning was measured by Hoogveld's et al. (2001) Role-Grid Scale.
The Expert's Assessment Scale was used to determine the quality of the designs that were produced by the participants after the training. It consisted of a general 9-item, 9-point scale, to assess the general design characteristics of each design, and a condition specific scale to assess the specific approach per condition.
The Evaluation of Approach Scale consisted of 50 items and was intended to measure the participants' opinion on the trained design approach. The items focused on the importance of the approach for the teacher trainers design practice. The scale included questions to control for the validity of the case.
The Retention Test used in the follow up experiment, consisted in each of the conditions of 13 multiple-choice four-item questions, discriminating between one correct and three wrong descriptions of the main characteristics of the approach. The sessions were videotaped and analyzed with The Observer Video-Pro software (Noldus Information Technology). In the ISD condition, the coding was based on the three main categories 'analysis', consisting of the subcategories hierarchical skill analysis, skill clustering and defining case types, 'working out learning tasks' consisting of the subcategories working out learning tasks and supportive information, and 'no input activity', which contained all non-screen activities (e.g., thinking, gazing, reading notes). The same main categories were distinguished in the EXP condition. The content of the category 'no input activity' was identical in both conditions. In the EXP condition, 'analysis' contained the subcategories of objectives, teaching concept, and teacher role. 'Working out learning tasks' was based on the categories definition of study task and output of the task.

Results

The experts' judgements of the design quality and the participants' evaluation rating of the trained instructional design approach were taken as dependent variables. During the 2-months experimental period a relatively large number of participants dropped out. From the 36 participants who started in this study, 31 returned the Preliminary Inquiry, 13 were able to complete the Evaluation of Approach Scale, and 9 finished the design assignment. Possible reasons for this large drop out will be given in the discussion section. The results are presented per measurement scale for the remaining participants.

The Preliminary Inquiry

Thirty-one participants responded to the preliminary inquiry, 18 in the ISD condition (14 men and 4 women) and 13 in the EXP condition (9 men and 4 women). The average experience of the participants as a teacher trainer was 10 years. The main reasons given for participation in the experiment were a general interest in being schooled in innovation of education, a specific interest in learning to design education, and an interest in tele-learning, schooling on the Internet. On the average, the respondents indicated that they were responsible for producing four study units per year. The attitude of the participants towards the design process of study units was measured with 14 Likert type items (Cronbach's Alpha = 0.57). A Mann-Whitney U test (Siegel, 1956), showed that the median scores for attitude towards the design process did not differ between the EXP and the ISD conditions ($U = 273$, $p > 0.05$).

The Role Grid Scale was comprised of 18 items to measure the amount of recognition, attached importance, and interest in training in six teaching roles that support process-oriented learning (see also Hoogveld et. al., 2001). Each items was expressed as a 9-point scale ranging from low (1) to high (9). The internal consistency of the items expressed as Cronbach's Alpha in this study was 0.89. The results on the Role Grid Scale reveal that in general the teachers recognize themselves the least in the roles of diagnostician and evaluator.

The Expert Assessment of Quality of Design Scale

The five designs produced by participants in the EXP condition and the eight designs from the ISD condition were assessed by two experts with help of the 15-item expert assessment scale for quality of design (Cronbach's Alpha = 0.93). Cohen's Kappa for inter-rater reliability was 0.42. The grand mean per condition per expert was calculated as the median of individual scores. A Mann-Whitney U test of these differences showed that the ratings of both experts for the ISD condition ($M = 8.0$) are significantly higher than the ratings of these experts for the EXP condition ($M = 5.8$; $U = 0$, $p < .05$).

The Evaluation of Approach Scale.
All scores, indiscriminate of condition, of the 13 remaining participants on the 50-item Evaluation of Approach scale were subjected to a data reducing Principal Component Factorial Analysis with Varimax rotation. This analysis resulted in a first factor, contributing to greater than or equal to 45 % of the total variance and second, third and fourth factors, each contributing to 10 % of the total variance. The first factor included 16 questions that relate to the central evaluation question: What is the possible significance of this approach for my design practice? A Mann-Whitney U-test on the median scores on these items revealed that the participants in the ISD condition rated the items of this first factor significantly higher than the participants in the EXP condition ($U = 7$; $n1 = 5$, $n2 = 8$, $p < .05$).

The follow up session.
Four persons participated in the follow-up session that was meant to get an impression of the differences in design processes as a function of the instructional design training condition. The analysis of the time spent on design activities of two cases in each condition offers some insight into the relative distribution of time across the different design activities. These data are presented in *Table 1*.
The results indicate that in the ISD condition substantially more time was spent on analysis activities and substantially less time on working out of study tasks than in the EXP condition. It should be noted that due to the low number of participants, no statistical tests were performed on these data.

Table 1 Percentage of design time spent during the different categories of activities in the design task in the follow-up study as a function of condition.

categories of design activities	**condition**	
	EXP	**ISD**
analysis	39	54
working out study tasks	27	12
gazing, thinking, seeking information	34	34

Discussion and Conclusions

This study compared the effects of a web-based training in an Instructional Systems Design approach to a web-based training in an experience-based design approach on the resulting design behaviour of Primary School Teacher Trainers. It was hypothesized that the resulting instructional designs of study units would be better in the ISD condition than in the EXP condition. Also, it was hypothesized that the ISD approach would be considered more relevant for their design practice than the EXP design approach. Both hypotheses were confirmed by the results.

In line with the expectations, the experimental follow-up sessions revealed a substantial difference in advantage of the ISD condition regarding the time spent on analysis activities during design of study units. This finding is consistent with the study of Hoogveld et al. (2002), in which the analysis and evaluation activities were identified as phases of the instructional design cycle to which teachers usually pay relatively little attention. The current findings suggest that training in an ISD design approach can change this in such a way that analysis activities will receive more attention, which is considered to be an important condition for the improvement of instructional designs in the new competency-based curricula.

Unfortunately, the experiment suffered from a large number of dropouts. We believe that the web-based character of the training approach was a main cause for this problem. The training via the web gave the participants a lot of freedom in dividing their time between the different activities and over the relatively long time available for the training and test. For the experimenters it was difficult to control this. Also, the fact that during the training and test periods there was no opportunity for face to face contact between the participants and between the participants and the tutors, appeared to be demotivating for the participants. Future studies using web-based training should take appropriate actions to prevent people from dropping out, either by shortening the duration of the experiment or by trying to increase the participants' commitment to the experiment. One way to increase the participants' commitment could be to plan face-to-face meetings on a regular basis during the training period. Another possibility that we are currently investigating is the use of a team approach. Working in teams is assumed to increase the social involvement of the individual team members.

The training in the reported deficiencies in instructional design skill that have been identified as a possible cause for the problems teachers of Dutch Polytechnics experience in designing competency-based education, seem to help alleviate that. The teachers appear to pay more attention to the activities of analyzing and evaluating. These activities are considered important for the design of instruction in the new learning-process oriented curricula. It can be argued that the 4C-ID approach effectively supports the teachers in the design of learning tasks for their students in the new curriculum. However, more research in this area is needed.

References

Clark, R. E., & Estes, F. (1999). The development of authentic educational technologies. *Educational Technology*, *39,* 5-16.

Dick, W., & Carey, L. (1996). *Instructional design: Theory and research.* (Vol 2). Hillsdale, NJ: Lawrence and Erlbaum.

Gagné, R. M., & Briggs, L. J. (1974). *Principles of instructional design*. New York: Holt Rinehart and Winston.

HBO-Raad. [Association of Universities of Professional Education] (1996). *Koers gekozen. Eindrapport van de vervolgvisitatiecommissie lerarenopleidingen basisonderwijs*. [Course determined. Final follow-up inspection report of Primary Teacher Training Colleges] (Sectorale kwaliteitszorg hbo, nr 28 en 33). Den Haag, The Netherlands: Voorlichtingsdienst HBO-Raad.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & van Merriënboer, J. J. G. (2002) Exploring teachers' instructional design practices: Implications for improving teacher training. *Instructional Science, 30,* 291-305.

Klauer, K. J. (1997). Instructional design theory: A field in the making. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design: International perspectives. Vol. 1* (pp. 447-455). Mahwah, NJ: London.

Leshin, C. B., Pollock, J., & Reigeluth, C. M. (1992). *Instructional design strategies and tactics.* Englewood Cliffs, NJ: Educational Technology Publications.

Moallem, M. (1998). An expert teacher's thinking and teaching and instructional design models and principles: an ethnographic study. *Educational Technology Research and Development, 46*, 37-64.

Noldus Information Technology. (2000). *The Observer Video-Pro 4.0* [Computer Software]. Wageningen, The Netherlands.

Romiszowski, A. (1981) *Designing Instructional Systems: Decision making in course planning and curriculum design.* London, New York: Kogan Page.

Rowland, G. (1992). What do instructional designers actually do? An initial investigation of expert practice. *Performance Improvement Quarterly, 2*, 65-86.

Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences*. New York: Mc Graw- Hill Book Company, Inc.

Tennyson, R. D. (2001). Defining core competencies of an instructional technologist. *Computers in Human Behavior*, *17*, 355-361.

Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills: A four-component instructional design model for technical training.* Englewood Cliffs, NJ: Educational Technology Publications.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9*, 257-280.

Zemke, R. (2000). Jeroen van Merriënboer, Quiet revolutionist. *Training, 37,* 44.

Chapter 4

Application of an Instructional Systems Design approach by teachers in higher education: Individual versus team design[2]

The differential effects of teachers' individual and collaborative performance on the application of an Instructional Systems Design (ISD) approach were investigated. Forty-two higher-education teachers were trained in an ISD approach and subsequently had to apply the approach both individually and as a member of a design team. The main hypothesis that the resulting collaborative designs would be better than individual designs was confirmed for low individual achievers but not for high individual achievers. In addition, a negative relationship between attitude towards the ISD approach and the attitude towards collaborative design was found. The implications of these results for a new role of the teacher as a designer are discussed.

The National Center for Education Statistics (NCES) has recently described Vocational Education at the turn of the century as an enterprise in transition (Levesque, Lauen, Teitelbaum, Librera, and M. P. R. Associates, Inc., 2000). The NCES report emphasizes the increasing importance of competency-based education (CBE) and concludes that the rapidly growing demand of competent employees does not match with the supply of competency-based Vocational Education in the U.S. A similar trend is noticeable in the Netherlands (HBO Raad, 2001a, 2001b).
CBE is aimed at providing students with the knowledge, skills, and attitudes that enable them to recognize and solve complex problems in their domain of study or future work, that is, authentic tasks (Keen, 1992). Examples of such tasks can be found in the competency-based curricula of

[2] Hoogveld, A. W. M., Paas, F., & Jochems, W. M. G. (in press). Application of an instructional systems design approach by teachers in higher education: individual versus team design. *Teaching and Teacher Education*.

Public Administration (Van Merriënboer, Bastiaens, and Hoogveld, in press) and Natural Sciences (Van Petegem, Sloep, Gerrissen, Jansen, and Schuwer, 2000) at the Open Universiteit Nederland. For instance, student policy advisors must learn to anticipate future decision making in the political context of the a big city's Administration by learning to collect all documentation that is possibly relevant and relating this to the decision formation process. To this end, the student policy advisors are confronted with such problems and the solutions of senior policy advisors. The natural sciences students participate in a web-based virtual office and must learn to analyze available information, search for new information about environmental incidents and environmental policy making in industrial companies.

The implication of the trend towards more competency-based education is that teachers will have to adopt the new roles of coach of the student's learning processes (Vermunt and Verloop, 1999; Samuelowicz, 2001) and designer of authentic learning experiences (Rowland, 1992; Rowland, Parra, and Basnet, 1994; Tennyson, 2001), and change their working style accordingly. Reigeluth and Avers (1997) and also Lang, Bünder, Hansen, Kysilka, Tillema, and Smith (1999) have emphasized the importance of the role of teachers as stakeholders in the design process of curricula. Consequently, teachers in higher education will be confronted with new instructional design problems associated with the translation of competency-based curriculum concepts into concrete learning tasks. Competency-based curricula for Higher Vocational Education focus on students' mastery of whole, complex, and authentic, job-oriented tasks. Instructional Systems Design (ISD) approaches are considered to offer opportunities to support the design of learning tasks for complex cognitive skills, and for the sequencing of these tasks throughout the curricula. Hoogveld, Paas, Jochems, and Van Merriënboer (2001) have shown that teachers experience difficulties in coping with these instructional design problems. Training teachers to use an ISD-approach has been identified as a possible solution to this problem (Hoogveld, Paas, Jochems, and Van Merriënboer, 2002). The study of Hoogveld et al., 2002 showed that a group of higher-education teachers that was trained to apply an ISD approach was able to design better learning tasks for CBE than another group that was trained to optimize their experience-based design approach.

This paper focuses on the question whether an ISD approach, once trained, can best be applied individually or in a team. In most Vocational Education Colleges the design of the curriculum is a matter of teamwork. So, it can be expected that the implementation of competency-based learning will be the responsibility of a team of teachers. However, the evidence regarding the surplus value of collaborative design is not conclusive. On the positive side, collaborative design approaches have been shown to be more successful than individual approaches (Sonnentag, Frese, Brodbeck, and Heinbokel, 1997). Furthermore, if the process of collaborative design is considered from the perspective of the research on individual learning versus collaborative learning, it can be expected to be more effective than individual design (Dillenbourg, Baker, Blaye, and O'Malley, 1996; Enkenberg, 2001). Another reason to arrive at the expectation that teamwork with an ISD approach results in better design performance than individual work can be found in the results of interaction analyses in collaborative learning research (Clark and Schaeffer, 1989). In this research, the shared understanding of meaning has been found to promote effective problem solving as an important step in the process of collaborative problem solving. On the negative side, there are indications that low achievers become progressively more passive when they work together with high achievers (e.g., Mulryan, 1992).

Finally, a reason for the expectation that collaborative work is more effective than individual work during instructional design with an ISD approach can be found in the Cognitive Load theory (Sweller, 1988; see for an overview also Sweller, van Merriënboer, and Paas, 1998). Cognitive Load theory is concerned with the development of instructional methods that efficiently use people's limited cognitive processing capacity to stimulate meaningful learning. Designing learning tasks for these highly integrated complex skills is expected to impose a very high load on the teacher's cognitive system, and may account for the problems teachers experience during the design of learning tasks for CBE. A potential solution to these problems can be found in a collaborative approach to design in small interdisciplinary teams. The holistic and integrative way of thinking that is required to design CBE forces teachers to look over the borders of the subject that they are used to teach in the knowledge-oriented curriculum. In practice stimulating teachers to work collaboratively on the design task can promote this process. In terms of cognitive load, the proposed interdisciplinary collaboration can increase the available cognitive capacity, and consequently, relatively decrease the cognitive load.

To gain more insight into the significance of collaborative design and individual design with an ISD approach, this study compares the design performance of individual teachers with that of collaborative teams of teachers. Because the positive results of collaborative work dominate in the referenced research, it is hypothesized that the resulting collaborative designs will be better than the individual designs. In addition, it is determined if collaborative design performance varies as a function of the quality of the individual design performance.

All teachers in this study are trained to apply the Four-Component Instructional Design (4C-ID) model of Van Merriënboer (1997), a well-recognized ISD methodology. This method especially supports and facilitates the design of complex cognitive skills in a whole-task approach. The 4C-ID approach provides methods and techniques for: (a) analyzing a complex cognitive skill into its constituent skills and their interrelationships, (b) analyzing the different knowledge structures that may be helpful or are required to be able to perform the constituent skills, and (c) designing a training blueprint, with as a base a sequence of whole task practice situations that support integration and coordination of the constituent skills. Authentic whole learning tasks, supportive info, just-in-time info and part task practice constitute the four components of the 4C-ID model. The basic element of a 4C-ID design is the *learning task*, which in the view of the method must always consist of the type of problems a practitioner in the domain normally has to solve. However, in complex domains, this level is often too high for students in the domain. According to the model, this might impose a cognitive overload on the limited working memory capacity of the learner, and, consequently, interfere with learning. The results of analyses of the task and the mental models and heuristics of expert problem solvers are used to program learning experiences with forms of the whole task, in such a way that cognitive overload is prevented. In the 4C-ID method this is attained by systematic control of the task complexity, by sequencing simple to complex forms of the whole task, and by fading the support within a level of same complexity. In addition, supportive information and JIT information are presented at the moments, the learners need it. Sometimes, when a high level of automation is required a series of learning tasks is programmed as *part-task practice*.

The 4C-ID model can be characterized as a relatively non-prescriptive ISD method. According to Klauer (1997) and Moallem (1998), who found that, in general, ISD methods are not very well accepted by teachers because of their prescriptive character, the 4C-ID method could be expected to be rather attractive to teachers. Detailed information on the 4C-ID methodology can be found in De Croock, Paas, Schlanbusch, and van Merriënboer (2002) and in Van Merriënboer, Clark, Moore, and de Croock (2002).

Method

Participants

The participants were 25 teachers (15 men and 10 women) from 18 faculties from 10 different institutes for higher education from all regions in the Netherlands. Their mean age was 43.4 years (*SD* = 7.3 years) and their average teaching experience was 12.2 years (*SD* = 9.3 years). All participants indicated to have 'some' instructional design experience and were involved or interested in being trained in an instructional design methodology for learning tasks in competency-based education. The participants were recruited by electronic mail and advertising. The one-day training in the 4C-ID methodology was offered to them in exchange for their participation in the experimental design test after the training.

Materials

Data were collected by means of a 14-item open answer questionnaire on general data regarding the teachers' attitude towards instructional design tasks, their experience in design of study units, the problems experienced during design of study units, their attitude to collaborative design, the type of task specialisation, and the number of study units they expect to design in the future. The attitude towards the 4C-ID method was measured on a 21-item five-point Likert scale that was based on the scale used by Hoogveld et al. (2001). The numerical values of this Attitude to Method (ATM) Scale ranged from '1' to '5', corresponding to the verbal labels of 'completely disagree' to 'completely agree'. The content of the items consisted of the general appreciation for, and, attractiveness of the trained methodology, the expected suitability of the method for solving design problems in the school context and the learn ability of the method and the ease of explaining it to interested colleagues. Nine items of the ATM scale, covering the same content, were chosen to compare the participants' attitude towards individual versus collaborative design with the 4C-ID method. This attitude towards collaborative design (ACD) scale was measured on the same 5-point Likert scale.

The design performance of the individual teachers and collaborative teams of teachers was measured independently by two experts on a scale containing two series of ratings on each of the seven design phases of the 4C-ID method. Participants' resulting design materials, of each design phase, such as the skill decompositions in graphical trees in Inspiration 5 Pro, and the clusters of skills, indicated by Venn diagrams in Inspiration, their descriptions of factors that complicate the task in Word for Windows, their descriptions of learning tasks and application of problem formats in Word for Windows, had to be rated on a 4-point scale with the following labels: 1 = very little or not, 2 = little or only partly, 3 = good, 4 = very good. Two experts, one of which was an independent expert in the 4C-ID methodology, not involved in the research project, and the other being the experimenter had to rate the test design materials of the participants, independently of each other. The ratings regarded the *recognition* of correct applications of the 4C-ID approach and the *quality* of the design. For example, in the phase of skill hierarchy, quality was related to the completeness of decomposition and the building of a logical hierarchy of sub skills. For the phase of skill clustering the quality was related to the extent to which the clusters of sub skills reduced the complexity of the main skill. In the phase of the task classes the quality was related to the correct identification of factors for task complexity and the correct application of these factors to create classes of learning tasks to master simple to complex forms of the whole complex task. In the learning task phase the quality was rated as the extent to which the participants were able to diminish the quantity of learner support by applying various problem formats. In the supportive information phase, the selection of the relevant cognitive strategies for normal task performance was the criterion for appropriate design. In the just-in-time information phase, the restriction to necessary information such as principles, knowledge, rules, to complete learning tasks was the criterion. Finally in the part-task training phase, the correct decisions to train or re-use recurrent skills was decisive for the quality of this phase.

Apart from these ratings, the experts had to rate the recognition as well as the quality of the total design on the same 4-point scales. For the overall rating of the total design the criterion for good designs discriminates in the consistent application of all the principles during the complete design, while for poor designs this is very little or not the case. During the rating process the experts had to use a rating protocol consisting of the exact descriptions of the rating values and the criteria for applying each of the score values as well.

All participants received a 12-hour training program on the 4C-ID methodology, supported by Powerpoint slides. The training, which took place in the multimedia laboratory of the Open Universiteit Nederland, was divided into three blocks of 4 hours, spread across one-and-a-half day.

The first part of the program consisted of the introduction and overview of the Four Component Instructional Design model, illustrated with two cases. The introduction was followed by a more elaborated explanation of each of the following seven phases of the 4C-ID design cycle: 1) hierarchical skill analysis, 2) skill clustering, 3) construction of task classes, 4) design of learning tasks in task classes and: 5) design of supportive information, 6) just-in-time information and 7) part-task training for these learning tasks. Each phase was explained and illustrated with a worked-out example of design of training for higher education students in searching for literature, a well-known complex skill in most higher-education programs. During the training the participants used an IBM-compatible computer with Microsoft Office software and Inspiration 5 Pro (1997, 1998) as tool for concept mapping. The design task during the training was divided into part-task training per phase and consisted of a blueprint, which participants had to construct for training in literature search. The concept-mapping tool was demonstrated just in time in the phases of hierarchical analysis and task clustering.
The test consisted of two design tasks: a) design training for a company rescue officer and b) design training for an ICT-helpdesk officer in a university or polytechnic. Both tasks represented relevant topics that were expected to challenge the participant teachers to design a short training program. Participants were not given details or further information about the task situation or professional performance criteria for the tasks. In both tasks the participants were asked to use the seven phases of the 4C-ID model. All design materials produced by individuals and teams were saved electronically for later expert assessment. Electronic versions of the scales measuring the attitude towards the 4C-ID method and the attitude towards collaborative design had to be answered.

Design and Procedure
Before the start of the training the participants had to complete the 14-item general-data questionnaire. All participants received the same training program. In a within-subjects design the participants were randomly

assigned to one of the two starting conditions; designing individually or designing in a small team.
After assignment to the conditions, each participant was randomly assigned to a team. In line with Cooper (1999), a team size of two or three teachers was considered optimal for design work. With regard to cooperation within a team, the team members were only required to decide about who is responsible for the data input of the design into the team's computer and who is responsible for the time management. So, after the training, half of the participants would start in the individual design condition, and then work in the collaborative design condition. The other half had to start with the design task in a team, and to end with the individual design task.
After attribution to a starting condition, participants were again randomly assigned to one of the two tasks to start with. This procedure was used to exclude possible effects of order in the design of the test. Differences in outcome therefore can be interpreted as differences of the experimental condition, where in each respondent has equal chance of starting individually or in a team and equal chance also to start with task 1 or task 2. During the training exercises the trainer was available for support. During the experimental design tasks the trainer was not available for support. Instead, all the demonstration materials and the training slides were available on the desktop of the computer.
The individual-design and collaborative-design condition as well started with a plenary explanation of the task and the procedure. This information was also available on paper and on the pc. In the collaborative design condition the participants were asked to assign an input-manager who would put in the design results discussed in the team and a time supervisor, who had to keep track of the available time. The individuals and groups had one-and-a-half hours available for each design task. After each task there was a 15 min. break.
After each of the design tasks the participants had to complete two scales measuring the attitude towards the 4C-ID method and the attitude towards collaborative design, respectively. All data were saved electronically.

Two trained experts/raters were asked to assess the participants' design results. The raters had to work following a securely defined rating protocol in which each rating act had to be commented.

Results

General characteristics of the respondents

The participants indicated that they had been producing on the average 2.5 study units per year during the last two years (individually = 1.2, team = 1.3). The average professional experience as a teacher was 12.5 years. The problems the participants had been experiencing during the design of study units, consisted of the constraints of continuous revision of units and simultaneously keeping up-to-date the expertise required for revision (N = 13); lack of adequate amount time for proper design (N = 15); no stimulation from colleagues during periods of innovation (N = 4); and problems in the selection of content. Overall, the participants preferred collaborative design or a mix of individual and collaborative design when designing study units (N = 41). On the average, the participants expect to produce 3.3 study units per year during the coming years.

Attitude towards the 4C-ID Method (ATM) Scale

The item consistency of the ATM scale determined by Cronbach's Alpha was 0.88. The mean scores of the items greater than the grand mean of all items (M = 3.6, SD = 0.1) are significantly different from the scores below the mean. More positive scores were obtained for the items that focus on the contribution of the method in solving design problems, on the estimated quality improvement of the study units, the amount of control over the coherence of parts of design, the attractiveness of the method, the clarity of the principles used in the method, the feeling of being a designer, the amount of support provided by the method, the estimated re-use, and the advisability of the method for other colleagues. Less positive scores were obtained for the items related to the ease of application of the method, the need for recurrent training in the method, the estimated capacity to explain the method to a colleague, the measure of concurrence with other methods, estimated efficiency, appropriateness for the type of design problems, usefulness for the whole school, and the need for more theoretical elaboration on the method. These findings are consistent with the findings in the earlier study of Hoogveld et al. (2001).

Attitude towards collaborative design (ACD) Scale

The item consistency of the ACD scale, determined by Cronbach's Alpha was 0.67. The grand mean for all items is 3.0 (SD = 0.15). Items that focus on quality of design have higher but not significantly higher mean scores than items that focus on collaborative design performance and design efficiency.

Relationship between the attitude towards the 4C-ID method and the attitude towards the collaborative design

Wilcoxon signed ranks tests on a stratification of the 42 ranked mean scores on the 9 comparable items of the ATM and the ACD scale into high and low stratum on the ATM scale, revealed that individuals with a high ranking on the ATM Scale are significantly lower ranked on the ACD Scale ($M_{rank\mathrm{ATM}} = 10.4$, $M_{rank\mathrm{ACD}} = 21.4$, $Z = -2.89$, $p < .004$) and that individuals with a low ranking on the ATM scale were ranked significantly higher on the ACDscale ($M_{rank\mathrm{ATM}} = 21.3$, $M_{rank\mathrm{ACD}} = 32.0$, $Z = -2.83$, $p < .005$). Note that 1 is the highest and 42 is the lowest ranking.

Design performance

The Average Measure Intra-class Correlation, determined across all the paired scores of both experts was .83. There was a significant correlation between the scores of both experts on 'recognition' of the application of the Four Component Instructional Design method and on the 'quality of design' (Pearson $r = .95$, $p < .001$). Therefore, the average of both types of scores can be used as a performance index. The hypothesis that collaborative design products would be better than individual design products was tested with a paired comparison T test of the average expert end-scores. The analysis revealed no significant differences in the overall design performance of participants in both conditions (t = -1.358, p < .182). To determine whether this effect was the same for low and high achievers the dataset was ranked from high to low individual performance and stratified into two equally sized groups of 21 participants each; the lower performance group representing the low achievers and the higher

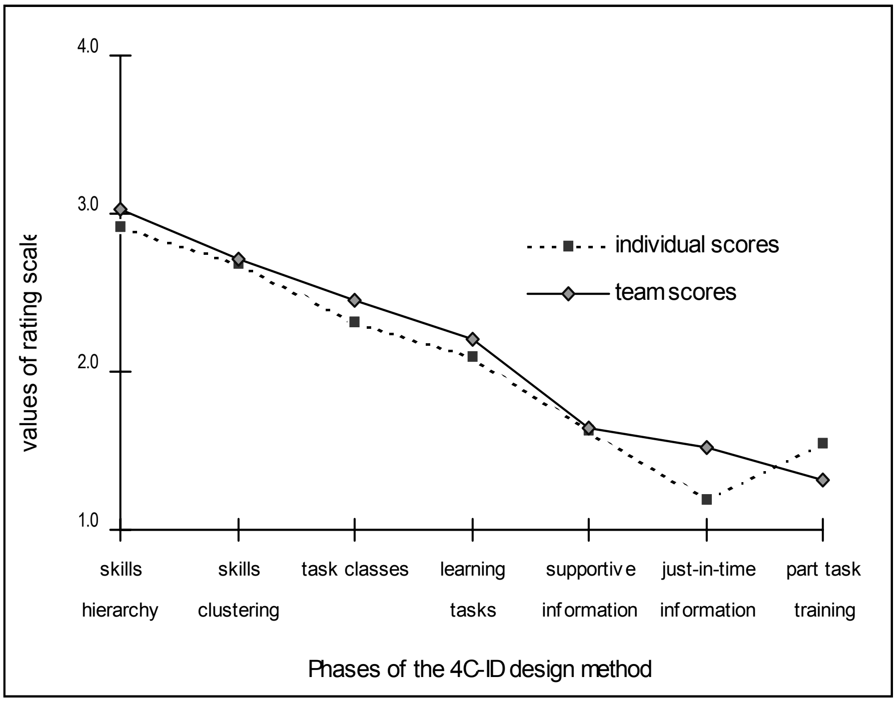

Figure 1. *Trend across design phases: mean individual and collaborative design phases.*

performance group representing the high achievers. Subsequently, this rank order was used to pair each individual score with the associated collaborative design score. Paired sample t-tests revealed that the design scores of the high individual achievers did not improve in the collaborative design condition ($M_{individual}$ = 2.8, M_{team} = 2.7, t = 0.42, p < .680), but that the low individual achievers improved significantly in the collaborative design condition (individual $M_{individual}$ = 2, M_{team} = 2.5, t = - 3.48, p < .002). Consistent with this finding, a similar analysis, now on the basis of sorting from the team point of view, revealed that the team scores of high achieving team members improved significantly compared with their individual scores, ($M_{individual} = 2.4$, $M_{team} = 3.5$, $t = -4.7$, $p < .00$), whereas the team scores of low achieving team members did not improve ($M_{individual} = 2.4$, $M_{team} = 2.1$, $t = 0.2.1$, $p < .51$).

Figure 1 shows a graphical representation of the means per design phase. Both the average and the individual expert mean scores of the participants on each of the design phases show very similar descending values from the first to the last phase. This trend was present in the individual and collaborative design conditions for the recognition scores, the quality scores, and for the end scores. The only exception on the trend was the part-task aspect of the design. These effects were tested with a linear regression curve fit function with each time the preceding design-phase mean score as independent and the subsequent score as dependent variable.

The results for the mean scores for the individual condition are presented in *Table 1* (see page 68), and the results for the collaborative design condition in *Table 2* (see page 68) . In the individual condition the trend is significant except for the just-in-time and part-task design phases and in the collaborative design condition the trend holds except for the part-task phase.

A paired sample t-test of the mean scores per phase, the mean for the first phase paired with the mean for the following phase and so on, revealed that all pairs, except the cluster-class phases, have significant differences. ($t_{hier\text{-}clust} = 3.2$, $p < .002$, $t_{clust\text{-}class} = 1.75$, $p < .088$, $t_{class\text{-}task} = .014$, $t_{task\text{-}supinfo} = 17.64$, $p < .0001$, $t_{suppinfo\text{-}jitinfo} = -13.09$, $p < .0001$, $t_{jitinfo\text{-}parttask} = 2.22$, $p < .032$).

A Wilcoxon signed-ranks test used for testing for differences in the same phase between conditions revealed significant effects only for the just-in-time and part task phases ($Z_{jit\ info} = -3.4$, $p < .001$, $Z_{part\text{-}task} = -2.052$, $p < .040$).

Relation design performance scale with other measures

There was a positive relationship between the collaborative design score and the experienced amount of support of the 4C-ID method in solving instructional design problems (Kendall's tau = .45, $p < .001$).

Table 1 Curve Fit of Individual Mean Scores per Design Phase

independent	**dependent**	***R*²**	***df***	***F***	***p***	***b0***	**b1**
hierarchy	clustering	.43	40	29.95	.000	1.07	.56
clustering	task classes	.12	40	5.54	.024	.79	.57
task classes	learning tasks	.11	40	4.61	.038	1.33	.34
learning tasks	supp info	.37	40	20.26	.000	.56	.51
supp info	jit info	.01	40	.43	.517	1.09	.07
jit info	part-task	.01	40	.42	.520	1.34	.14

Table 2 Curve Fit of Collaborative Mean Scores per Design Phase

independent	**dependent**	***R*²**	***df***	***F***	***p***	***b0***	**b1**
hierarchy	clustering	.39	40	25.14	.000	33	.80
clustering	task classes	.34	40	20.54	.000	.42	.77
task classes	learning tasks	.55	40	49.11	.000	.67	.64
learning tasks	supp info	.20	40	9.67	.003	.06	.04
supp info	jit info	.26	40	13.95	.001	.89	4.39
jit info	part-task	.02	40	.10	.757	1.35	- 0.03

The relation between pleasure in collaborative work and the design performance score was not significant. (Kendall's $Tau_{high} = .27$, $p < .24$, $Tau_{mid} = .00$, $p < .1$, $Tau_{low} = -.19$, $p < 1.00$).

Discussion and conclusions

Hoogveld et al. (2002) have identified the training in an ISD design methodology as a potential solution for the problems that teachers in higher vocational education experience in implementing the principles of competency based education in their curricula. The application of such a methodology in the form of designing concrete learning tasks usually is a matter of team collaboration. Because it is not clear whether the design results of this collaborative effort is superior to those of individual design efforts, this study trained teachers in using an ISD methodology and compared the effectiveness of its application individually or in a team. The results of the experiment revealed that only low individual achievers could profit from collaborative design work, while low team achievers do not. For high individual achievers there was no advantage of working in a team. High team achievers perform better in the team than as an individual. The fact that less good designers seem to benefit from the good designers and that good designers do not experience this as a disadvantage can be interpreted as an advantage of a collaborative approach where teachers work together in teams. However, in terms of efficiency it should be noted that the collaborative design teams worked just as long as the individual designers did. From this point of view, it could be argued that the educational institutions should identify the teachers who are good designers and let them do the design work. On the other hand it could be investigated whether the teachers who were identified as less good designers can be trained to become good designers.

The other results of this experiment give more insight into the attitude of teachers towards the application of ISD methods, and specifically the 4C-ID methodology. The attitude towards the method (ATM) and to collaborative design work (ACD) varied both from generally positive to neutral, respectively. Remarkably, a significant negative relationship was found between the attitude towards the ISD approach and the attitude towards collaborative design. High scores on the attitude to method were associated with low scores on the attitude to collaborative design and vice versa. It could be that it was the low achievers who liked to work in a team because they expect to profit from the methodological input of high achievers. Therefore, the latter group has to invest extra effort to master the method and communicate it to the low achievers. Consequently, the high achievers might be expected to be more interested in individual work.

In terms of cognitive load theory (Sweller et al., 1998), the present results suggest that collaborative design performance is beneficial to the low achievers and imposes an extra load on the cognitive capacity of the high achievers. It seems that within a group, the quality of the output cannot solely be predicted by the sum of the cognitive capacities of the different group members. The relation between group work and the associated cognitive load represents an important topic for future research.

Curiously, in both the individual and the collaborative design conditions, the design performance decreased significantly from the first to the last step in the design-methodology. This trend might be explained by the increasing complexity of the methodology in each new design step, by incomplete mastery of the methodology, and by the contrast to their own methodology, resulting in high cognitive load during the application of the method, introducing time pressure later in the design cycle. The tendency of teachers to directly translate skills into learning tasks instead of completing the design cycle, as shown in an earlier experiment (Hoogveld et al., 2001) may also partly explain the decline in performance scores. A final alternative explanation relates to a kind of snowball-effect, which is caused by an improper or incomplete hierarchical analysis in the beginning of the design and its increasing negative consequences for later steps in the design.

The relatively short duration of the training and application in this study, as well as the laboratory setting are also factors that need to be considered in explaining the present results. It is clear that a complex methodology like the 4C-ID method can only be mastered after a few days of training and that the proper application can only be tested in a ecologically valid environment like the school. So, the question is whether the same results would have been found with a longer duration of the training, with more time to apply what was learned, and in a school setting. This question can only be answered in future research.

To conclude, the hypothesis that the collaborative application of a trained ISD method to the design of learning tasks results in better design performance than the individual application, could only be confirmed for the low individual design achievers and high collaborative team designers.

It is clear that this study is only a first step in the identification of methods that can enable teachers to cope effectively with their new role of instructional designer in the translation process from competency-based curriculum concepts into concrete learning tasks.

References

Clark, H. H., & Schaeffer, E. F. (1989). Contributing to discourse. *Cognitive Science, 13,* 259-294.

Cooper, A. (1999). *The inmates are running the asylum. Why high-tech products drive us crazy and how to restore the sanity.* Indianapolis, IN: Sams.

De Croock, M. B. M., Paas, F., Schlanbusch, H., & Van Merriënboer, J. J. G. (2002). ADAPT[IT]: Computerized tools for the design of personalized training for complex cognitive skills. *Educational Technology Research & Development. 50,* 47-58.

Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada & P. Reimann (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science* (pp. 189-211). Oxford: Elsevier.

Enkenberg, J. (2001). Instructional design and emerging teaching models in higher education. *Computers in Human Behavior, 17,* 495-506.

HBO-Raad [Association of Universities of Professional Education] (2001a). *Kengetallen*. [Statistical information]. The Hague, the Netherlands: HBO-Raad.

HBO-Raad [Association of Universities of Professional Education]. (2001b). *Het hbo ontcijferd.* [Universities of Professional Education in Digits]. The Hague, the Netherlands: HBO-Raad.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merriënboer, J. J. G. (2001). The effects of a web-based training in an instructional systems design approach on teachers' instructional design behavior. *Computers in Human Behavior 17,* 363-371.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merriënboer, J. J. G. (2002). Exploring teachers' instructional design practices from a systems design perspective. *Instructional Science, 30* (4), 291-305.

Inspiration Inc. (1997, 1998). *Inspiration Pro* (Version 5). [Computer software]. Beaverton Hillsdale Hwy, Portland.

Keen, K. (1992). Competence: What is it and how can it be developed? In J. Lowyck, P. De Potter & J. Elen (Eds.), *Instructional Design: Implementation issues* (pp. 111-122). Brussels: IBM International Education Center.

Klauer, K. J. (1997). Instructional design theory: A field in the making. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Series Eds.), *Instructional design: International perspectives: Vol. 1.* (pp. 447-455). Mahwah, N.J.: London.

Lang, M., Bünder, W., Hansen, H., Kysilka, M. L., Tillema, H., & Smith, K. (1999). Teacher professional development in the context of curriculum reform. In M. Lang, J. Olson, H. Hansen, and W. Bünder (Eds.), *Changing schools/Changing practices: Recent research on Teacher professionalism.* Louvain, Belgium: Garant.

Levesque, K., Lauen, D., Teitelbaum, P. A. M., Librera, S., & M. P. R. Associates, Inc. (2000). *Vocational education in the United States: Toward the year 2000* (Report Nr. 029). Washington D.C.: U.S. Department of Education. Office of Educational Research and Improvement.

Moallem, M., & Earle, R. S. (1998). Instructional design models and teacher thinking: toward a new conceptual model for research an development. *Educational Technology, 38*, 5-22.

Mulryan, C. M. (1992). Student passivity during cooperative small group in mathematics. *Journal of Educational Research, 8,* 261-273.

Reigeluth, C. M., & Avers, D. (1997). Educational technologists, chamelions, and systemic thinking. In R. M. Branch and B. B. Minor (Eds.), *Educational media and technology yearbook, Vol 22*. (pp. 132-137). Englewood Cliffs, NJ.: Educational Technology Publications.

Rowland, G. (1992). What do instructional designers actually do? An initial investigation of expert practice. *Performance Improvement Quarterly, 5*(2), 65-86.

Rowland, G., Parra, M. L., & Basnet, K. (1994). Educating instructional designers: different methods for different outcomes. *Educational Technology, 34*(6), 5-11.

Samuelowicz, K. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41,* 299-325.

Sonnentag, S., Frese, M., Brodbeck, F. C., & Heinbokel, T. (1997). Use of design methods, team leaders' goal orientation, and team effectiveness: A follow-up study in software development projects. *International Journal of Human-Computer Interaction, 9*, 443-454.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12,* 257-285.

Sweller, J., Van Merrienboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10,* 251-295.

Tennyson, R. D. (2001). Defining core competencies of an instructional technologist. *Computers in Human Behavior, 17,* 355-361.

Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills: A four-component instructional design model for technical training.* Englewood Cliffs, NJ: Educational Technology Publications.

Van Merriënboer, J. J. G., Bastiaens, Th., & Hoogveld, A. W. M. (in press). Instructional design for integrated e-learning. In W. M. G. Jochems, J. J. G. Van Merrienboer, & E. J. R. Koper (Eds.), *Integrated e-learning.* London: Kogan Page.

Van Merriënboer, J. J. G., Clark, R. E., Moore, J. A. & de Croock, M. B. M. (2002). Blueprints for complex learning: The 4C-ID-model. *Educational Technology Research & Development, 50*(2), 39-64.

Van Merriënboer, J. J. G., & Kirschner, P. A. (2001). Three worlds of instructional design: state of the art and future directions. *Instructional Science, 29,* 429-441.

Van Petegem, W., Sloep, P., Gerrissen, J., Jansen, D., & Schuwer, R. (2000). Virtual business teams for professional development and team learning. In: S. D. Franklin & E. Strenski (Eds.), *Building university electronic educational environments*. (pp. 67-78). Irvine, Ca.: Kluwer.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9,* 257-280.

Chapter 5

Training higher-education teachers for instructional design of competency-based education: Product-oriented versus process-oriented worked examples[4]

Teachers involved in the development of competency-based higher education (CBE) are expected to fulfil a new role of instructional designer. As a consequence, they are confronted with the problem to translate abstract new curriculum principles into concrete learning tasks. Recent studies have shown that teachers can be trained to apply an instructional systems design methodology (ISD: Hoogveld et al., 2001, 2002b). After this training the teachers were able to design better learning tasks for CBE in comparison with their experienced-based design efforts. In order to optimise the training, this study compares an experimental condition with process-oriented worked examples with a conventional training condition with emphasis on product-oriented worked examples. After the training, the participants - 25 higher-education teachers - had to apply the ISD methodology to two design problems. The quality of the resulting design materials, as rated by experts, was higher in the product-oriented worked examples condition than in the process-oriented worked examples condition. The significance of this finding for the training approach for design methodology for CBE is discussed.

In the last decade, a trend can be observed in the field of higher education from knowledge-oriented to competency-based education (CBE) (Barnett, 1994; Vermunt and Verloop, 1999; Levesque, Lauen, Teitelbaum, Librera, and M. P. R. Associates, 2000; Arguelles and Gonczi, 2000; Achtenhagen, 2001; Samuelowicz, 2001). CBE is aimed at providing

[4] Hoogveld, A. W. M., Paas, F., & Jochems, W. M. G. (2002). Training higher education teachers for instructional design of competency-based education: product-oriented versus process-oriented worked examples. Manuscript submitted for publication.

students with the knowledge, skills, and attitudes to enable them to recognize and solve complex problems in their domain of study or future work, i.e., authentic tasks (Keen, 1992). Whereas knowledge-oriented education focused on the question of what needs to be taught and learned in terms of concepts and conceptual structures, within CBE the questions of why something has to be learned and how it can be used in solving a complex problem are considered important. Knowledge application, problem solving and heuristics are key topics of CBE.

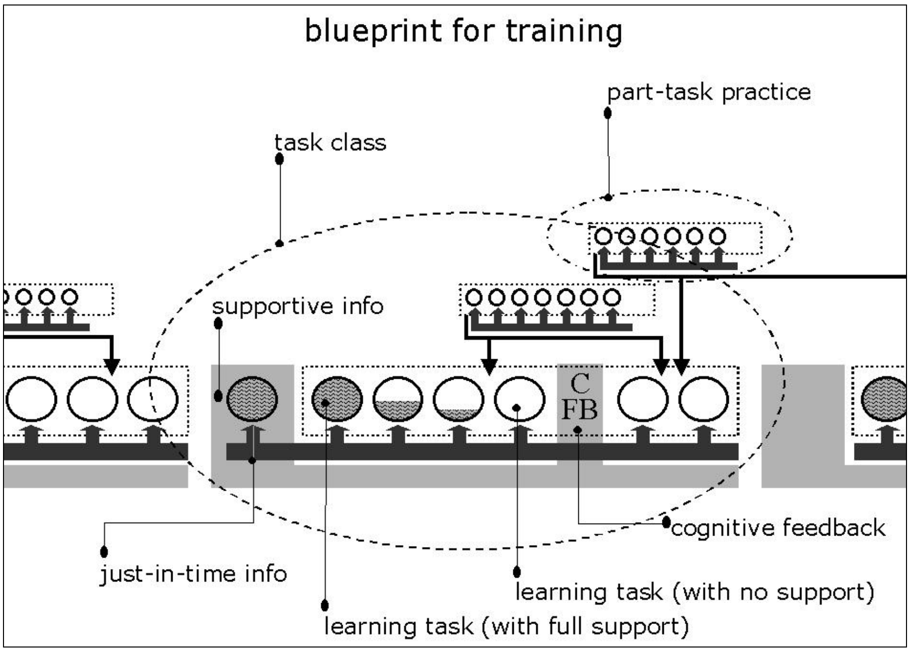

Figure 1 Schematic representation of a training-blueprint created with the 4C-ID methodology. Adapted from Van Merriënboer, Clark and de Croock (2002).

The successful realization of CBE heavily relies on the teachers, who are expected to give up their role as 'knowledge transmitter' and adopt the new roles of 'coach' (Kerr, 1996; Pratt and Associates, 1998; Enkenberg, 2001; Samuelowicz, 2001), and 'instructional designer' (Tennyson, 2001). Particularly, in the new role of instructional designer, teachers are confronted with the difficult task to translate abstract new curriculum principles into a meaningful sequence of authentic learning tasks. The creation of this type of learning tasks and its prerequisite competency analysis has been identified as the teachers' major design challenge of the transition process from knowledge- to competency-based higher education (Hoogveld et al., 2001). In general, teachers are not well equipped with the appropriate skills for this complex design task. Hoogveld et al. (2001) have shown that in the intuitive, experienced-based design approach of teachers only little attention is paid to the phases of analysis and evaluation. Since, the analysis of the competency is considered crucial for effective instructional design for CBE, they argued that an Instructional Systems Design (ISD) approach with an emphasis on task analysis could offer a solution to the problem. In line with this argument, Tennyson (2001) has stated that competency in ISD methodology can be considered as one of the three basic core knowledge areas that need to be mastered by teachers to cope with the learning-process oriented teaching principles in designing CBE. Hoogveld et al. (2001) studied the effects of training in the four-component Instructional Systems Design methodology (4C-ID) of Van Merriënboer (1997) on higher-education teachers' design performance compared to this teachers' experience-based design approach. They found that with the 4C-ID training the teachers were better able to cope with the instructional design requirements of CBE.

The 4C-ID Model (van Merriënboer, 1997) is an Instructional Systems Design methodology that is developed especially for supporting design of learning tasks for CBE (Janssen-Noordman and van Merriënboer, 2002). It focuses on the development of learning environments for complex cognitive skills or professional competencies. Like other modern instructional design models, it assumes that rich learning tasks are the driving force for learning. The methodology is learning process oriented (Clark and Estes, 1999) and non-prescriptive. As a result, it is attractive for teachers, who in general are not inclined to use Instructional Systems Design models because of their prescriptive character (Klauer, 1997; Moallem, 1998).

The output of the 4C-ID methodology is a blueprint of a training (see *Figure 1*), which contains learning tasks, organized as authentic and meaningful whole-task experiences to promote construction of cognitive schemata.

Learning tasks are sequenced in 'task classes', which represent sets of simple-to-complex instances of the whole task. Each task class of the training blueprint thus consists of a series of learning-tasks which are of the same level of task complexity and which are sequenced according to a descending amount of learner support. A unit of Supportive Information, in which it is explained how domains are organized and how problems in the domain are to be approached precedes each task class. Each learning task is provided with Just-In-Time-information, referring to the task's recurrent aspects and specified algorithmically, at the moment, needed during task performance. When necessary, part-task practice, consisting of repetitive practice of recurrent tasks that require a high level of automation is provided in the blueprint of the training (van Merriënboer, Clark, and de Croock, 2002; van Merriënboer and de Croock, 2002).

Contemporary instructional theories focus on complex, realistic tasks as the driving force for learning. This type of tasks is applied in context-based learning, which is based on the concept of situated of knowledge and experience. Complex tasks require of practitioners in complex domains the ability to see the domain system as a unified whole (Spector, 2001). It is this characteristic of professional expertise in a domain that causes practical problems for teachers and instructional designers in realizing CBE. The student with little expertise in the domain or in the task will not have any overview or will not be able to see the whole, while working at a detailed realistic task.

An important characteristic of CBE, which adds a lot of complexity to the teachers' design task, is its focus on authentic whole tasks as the driving force for learning (Van Merriënboer and Kirschner, 2001). Whole-task approaches to the design of learning tasks focus on the coordination and integration of constituent skills from the very beginning, and stress that learners quickly develop a holistic vision of the whole task during the training. This form of complex learning is always involved with achieving highly integrated sets of learning goals. Complex learning has little to do with learning separate skills in isolation, but it is foremost dealing with learning to coordinate the separate skills that constitute real-life task performance. Thus, in complex learning the whole is clearly more than the sum of its parts because it also includes the ability to coordinate the parts. Complex learning stresses that effective performance relies on an integration of skills, knowledge and attitudes.

Two interrelated solutions have been identified by Hoogveld et al. (2002a, 2002b) to enable teachers to deal with the integrative design demands of competency-based curricula. Because of lacking experience in the important analysis- and evaluation- phases of design one solution is training teachers to use an appropriate instructional design model such as the 4C-ID methodology. Another one is using collaboration to lower the integrative complexity for the individual teacher. Teachers supported by the 4C-ID methodology can collaborate on the design task and contribute to the design task by providing input from their specific disciplines. Whereas the first solution was confirmed in a study of Hoogveld et al. (2001), the latter solution was investigated by Hoogveld et al. (2002a) by comparing design performance of individual teachers to that of small teams of teachers. In general, team design performance did not differ significantly from individual design performance. However, whereas low individual design performers showed better design performance in a team, for high individual design performers the collaborative approach had no added value. Although under certain circumstances it might be better to have a good individual teacher/designer do the job, the general conclusion of the study was that applying the 4C-ID methodology in a team is recommendable for higher-education teachers.

In this study, besides the collaborative design approach, the quality of the teacher training in the 4C-ID methodology is identified as a potentially important factor determining the quality of the design for CBE. We explore the effects of an alternative training approach for the 4C-ID methodology on the design of learning tasks for CBE. The alternative strategy logically followed from the studies of Hoogveld et al. (2002a, b), in which conventional product-oriented worked examples (WEs) were used to train the 4C-ID methodology. With this type of worked examples, students have to study the problem state, the goal state, and an expert's problem solution. During the mentioned studies the experimenter was regularly confronted with participants asking 'how' and 'why' questions when studying the worked examples. This instructional method with product-oriented WEs, based on Cognitive Load theory (Sweller, 1988), has been found to be very effective in the training of complex cognitive tasks as compared to traditional problem solving (for an overview see, Sweller, van Merriënboer, and Paas, 1998). Cognitive load theory is concerned with the instructional implications of the interaction between information structures and cognitive architecture.

However, recent research within the cognitive load framework focuses more and more on the optimal design of WEs (Atkinson, Renkl, Derry, and Wortham, 2000). The conventional WEs typically present the problem and its solution in terms of (intermediary) products, but not the processes of *how* these products are attained and *why* they are attained this way. The alternative training approach in this exploratory study consisted of process-oriented worked examples, which show how instructional design experts solve the problem and why they solved the problem that way (cf. Braaksma, Rijlaarsdam and van den Berg, 2002). These process-oriented WEs are comparable to modeling examples, which are theoretically grounded in the concepts of observational learning (Bandura, 1986) and apprenticeship learning (Collins, Brown, and Newman, 1989). On an exploratory basis we determined the differential effects on the design of learning tasks for CBE of a teacher training with product-oriented WEs and an alternative training with process-oriented WEs. The research question thus can be reformulated as whether a process-oriented WE condition or a product-oriented worked-out example condition leads to better learning tasks.

Method

Subjects

The participants were 25 teachers (15 men and 10 women) from 13 different Dutch higher education branches of study. Their mean age was 43.4 years (*SD* = 7.3 years) and their average teaching experience was 12.2 years (*SD* = 9.3 years). All participants indicated to have 'some' instructional design experience. The participants were recruited by electronic mail and advertising. The one-day training in the 4C-ID methodology was offered to them in exchange for their participation in the experimental design test after the training.

Materials

The materials used in this experiment consisted of the training materials, two test tasks, three inquiries to measure subject characteristics, experiences with and opinions about the method, a Quality Scale to measure the design performance on the test tasks, including a Quality Scale protocol for determining design performance, and an Application Scale to determine the extent to which the design complies with the 4C-ID methodology. The training materials consisted of the PowerPoint-slides for the basic instruction, which was similar for both conditions and which consisted of presentation and explanation of the goals, elements, concepts and phases of the design approach.

The condition-specific materials for the process-oriented worked example (Process-WE) condition consisted of two videotapes, which were produced to show the two design processes carried out by two 4C-ID design-experts, who created learning tasks for the process-oriented worked example design problem. In the first example the design problem was to teach students how to search for literature. In the second example the design problem referred to the teaching of a beginning help desk operator how to handle computer problems. The videotapes showed how the instructional design experts map the specific competencies in these fields of expertise by interrogating an experienced literature researcher and a help desk officer.

The video recording showed a split-screen containing the screen of the computer, the experts used during design and the design expert interacting with the domain expert. A zooming technique was used to emphasize relevant aspects of the design process. Furthermore, for each of the Process-WEs, the materials contained the PowerPoint-slides, which had to support the instructor's review of the rules of thumb, the experts applied in the example.
The condition-specific instructional materials for the Product-WE condition consisted of PowerPoint-slides showing the product-oriented approach for teaching students how to search for literature. It also included a paper with a description of a design problem, with which the participants had to exercise the principles of the worked-out example. This last design problem consisted of teaching a beginning help-desk operator how to handle computer problems. The two test design tasks consisted of a written description of the design problem and the design criteria to be applied. One test task required the participants to design training for driving a car. The other test task to design training for students in the verbal presentation of a project paper. The training of the participants as well as the test tasks was organized in the multimedia test laboratory of the Educational Technology Expertise Center of the Open Universiteit Nederland. During the elaboration of the test design tasks by the trainer/experimenter the instructional materials and the task description were available on the participant's computer. The videotapes for the Process-WE condition could be watched in an adjoining room on a large video screen (approximately 100-cm).
Three inquiries were constructed. The first inquiry collected the participants' individual characteristics such as age, teaching experience, and design experience. The second inquiry was developed to collect the personal experience of problems by the participants during the test. It consisted of open questions referring to their success in finding the solution to the design problems, their satisfaction with the design results, the difficulties they met during the test design task, the differences with their current practice, and the usefulness of the trained approach for their jobs.

The third inquiry measured the participants' opinions about the 4C-ID methodology with an open question. It also consisted of 13 Likert-type scale ratings about their perceived basic insight in the trained approach, the pleasure of studying the approach, the appropriateness of the method to construct CBE, the attractiveness of the approach for them, the ease of learning the approach, their degree of mastery of the methodology, the possibility for them to reuse the method, their need for more training in the methodology, their need for more theoretical background knowledge about the method, the level of resemblance with existing approaches in their school, the estimated ease of explaining the method to colleagues, the level of recommendation of the method to colleagues, and the acceptance of the experimenter's offer for future advise about applying the method to an existing problem.
A Quality Scale was developed to measure the design performance of the participants on the test design tasks. The instrument to be used by design experts consisted of a five-point scale to rate the quality of the participants' design results. The values and associated verbal labels of the scale were as follows: 0, for absence of material; 1, for very little or hardly quality of design; 2, for little or only partly quality of design; 3, for sufficient quality of design; 4, for excellent quality of design. The scale had to be applied to each of the three design phases of the methodology, hierarchical analysis, task classes and learning tasks. The scale was also used to give an overall rating of the participants' design performance. The scale had to be applied in combination with a rating protocol, which describes the criteria to decide between the different scale values.
An Application Scale was constructed to measure the extent to which the design complies with the 4C-ID methodology. For each step in the design materials of the test task of the participants that matched with the steps shown in the instruction, a score of 1 was given; in absence of this match a score of 0 was awarded. The summation of all scores was considered as an index of compliance with the method.

Design and procedure

A Process-WE condition of the training in the 4C-ID methodology was compared to a Product-WE condition of the same training. In the Product-WE condition a worked-out example was followed by a practice design problem for which the participants had to generate a solution. The Process-WE approach consisted of two videotaped Process-WEs, followed by a recapitulation by the trainer of the used principles and rules of thumb.

In both conditions the same basic instruction and test problems were given, respectively, before and after the differential treatment. The 25 participants were randomly assigned to one of the two experimental conditions. Four consecutive training days were planned, two for each condition, containing 6 or 7 participants.

Two experts in instructional design with the 4C-ID methodology were trained in applying the rating protocol to the participants' design materials. Design materials were prepared in such a way that the two experts were unaware of the participants' identity and the experimental conditions. Experts had to rate the design materials independently.

Results

The data set of this experiment consists of the experts' ratings on the Quality Scale, the scores on the Application Scale, the participants' answers on the inquiries to measure subject characteristics, experiences with and opinions about the method. Random attribution of participants to research conditions resulted in 13 participants in the process-WE and 12 in the product-WE condition. The differences between the experimental conditions were analyzed non-parametrically, using two-sided Mann-Whitney U-tests. Note that in the results presented below with the statistic *M,* the Mean rank is meant all over again. The reliability of the expert ratings was estimated using the Intra-Class Correlation Coefficient as described by Shrout and Fleiss (1979). The average measure Intra-class coefficient between all paired scores of both experts was 0.71. Cronbach's Alpha was 0.72. The mean score of the experts was used to determine effects of the different treatments on design performance.

Design performance

With regard to the performance on the test design tasks as measured with the Quality Scale, the Product-WE condition performed significantly better than the Process-WE condition, as well for the overall design performance (Process-WE M = 10.1, Product-WE M = 16.1, U = 40.5, Z = -2.08, p < .038) as for the design of learning tasks (Process-WE M = 9.6, Product-WE M = 16.7, U = 33.5, Z = -2.45, p < .014). No significant between-conditions differences were found for the 4C-ID phases of creating a hierarchical skill analysis (Process-WE M = 11.6, Product-WE M = 14.5, U = 59.5, Z = - 1.02, p < .307) and of the design of task-classes (Process-WE M = 11.0, Product-WE M = 15.1, U = 52.5, Z = - 1.43, p < .153).

With regard to the ratings of compliance to the 4C-ID method as measured with the Application Scale, the results showed a significant difference between conditions in favor of the Product-WE condition (Process-WE M = 10.2, Product-WE M = 16.1, U = 41, Z = -2.017, p < .008).

Inquiries and evaluation

The answers on the first and second after test-task inquiries, which were identical, were coded as 1) yes, 2) no, or 3) neither yes nor no. No between-conditions differences were found for the summarized test items about the teachers' perceived success in solving the design problems (Process M = 14.1, Product-WE M = 11.9, U = 64.5, Z = -.86, p < .389), their satisfaction with the design results (Process-WE M = 14.0, Product-WE M = 11.9, U = 65.0, Z = -.76, p < .446), and differences with their current practice (Process-WE M = 13.5, Product-WE M = 12.5, U = 72.0, Z = -.37, p < .710).

The test task scores with regard to the participants' perceived usefulness of the 4C-ID methodology for solving problems in their jobs, revealed a significant advantage of the Process-WE condition (Process-WE M = 15.5, Product-WE M = 9.5, U = 36, Z = - 2.40, p < .016).

Participants' opinions about the 4C-ID method were collected with the third inventory after the last test design-task. The first item, evaluation of the method, had to be answered with an open question. The answers on the other items were given on a five-point scale. The answers on the open question about the 4C-ID methodology were overall positive with some critical remarks added. The answers on the five-point scale differed significantly with regard to the pleasure the teachers felt of being trained in the 4C-ID methodology (Process-WE M = 9.3, Product-WE M = 17.0, U = 30, Z = -2.96, p < .03) and with regard to the perceived appropriateness of the method to construct CBE (Process-WE M = 10.4, Product-WE M = 15.8, U = 43.5, Z = -2.08, p < .038).

No significant between-condition effects (all U-values > 43,5, all p's > . 05) were found for the teachers' opinions about their basic insight in the trained approach (Process-WE M = 12.4, Product-WE M = 13.7), the attractiveness of the approach (Process-WE M = 11.9, Product-WE M = 14.2), the ease of learning the approach (Process-WE M = 13.5, Product-WE M = 12.5), the degree of mastery of the methodology (Process-WE M = 11.7, Product-WE M = 14.3), the possibility for them to reuse the method (Process-WE M = 10.5, Product-WE M = 15.8), their need for more training in the methodology (Process-WE M = 11.6, Product-WE M = 14.5), their need for more theoretical background knowledge about the method (Process-WE M = 12.4, Product-WE M = 13.7), the level of concurrence with existing approaches in their school (Process-WE M = 15.6, Product-WE M = 10.2), the estimated ease of explaining the method to colleagues (Process-WE M = 14.1, Product-WE M = 11.8), the level of recommendation of the method to colleagues (Process-WE M = 12.7, Product-WE M = 13.3), and the acceptance of the experimenter's offer for advise about applying the method to an existing problem (Process-WE M = 13.1, Product-WE M = 12.8).

Discussion and conclusions

An experiment was set up to compare the effectiveness of training with process-oriented worked examples (Process-WEs) to training with product-oriented worked examples (Product-WEs) for the design of competency-based education by higher-education teachers. Teacher training in the 4C-ID methodology of Van Merriënboer (1997) with product-oriented worked examples has been identified as a viable solution to the problem teachers experience when requested to design instruction for CBE. After this type of training, teachers are able to design learning tasks for a competency-based curriculum, either individually or in small design teams (Hoogveld et al., 2002a, b). This study was triggered by an important observation during these experiments, namely that the participants frequently indicated that they would like to receive process-based information regarding the 'how' and 'why' of the solution steps that were presented in the worked examples. The current exploratory study compared such an experimental training strategy with process-oriented worked examples to the previously used strategy with product-oriented worked examples.

The results based upon expert ratings of the quality of the design materials clearly show that the overall design and, in particular, the design of learning tasks was better when teachers were trained with conventional product-oriented worked examples than with process-oriented worked examples. Consistent with this finding, the results based upon the measured correct application of the trained steps and parts of the methodology indicated that the Product-WE condition over performed the Process-WE condition. Similar results were found with regard to the participants' perceived pleasure to explore the method and on the perceived usefulness of the methodology to create CBE. Only one finding seemed to be inconsistent with the general superiority of the Product-WE condition, namely, the extent to which the teachers feel that the 4C-ID methodology provides a solution to design problem in their own school situation. Here the participants of the process-WE condition showed more confidence. To conclude, this experiment is a confirmation for the existing evidence that product-oriented worked examples represent a powerful means of training within CBE.

The first possible explanation for the advantage of product-oriented worked examples is based on cognitive load theory. Although the process-based information represents a relevant cognitive load, which can be expected to improve learning, the combination of the complex design task and the 'how' and 'why' information might have exceeded the available cognitive capacity of the teachers. In terms of cognitive load theory this situation can be considered as overload. In future research it would be interesting to measure the level of cognitive load (Paas, Tuovinen, Tabbers and Van Gerven, 2002) to validate this assumption.

Another explanation of the results is that the process-based information as verbalized by the experts was too implicit and contained 'noise'. Whereas the product-based information was explicitly presented in the product-oriented worked examples, the process-based information was presented less explicit in a videotaped natural dialogue between the expert and the professional. As a result of this dialogue the process-based information was also surrounded by information that was not directly relevant to the task at hand, so called noise. Consistent with this line of reasoning, video observation learning experiments (Jentsch, Bowers, and Salas, 2001) have shown that the recognition of relevant expert behavior requires a minimum level of work experience and that inexperienced people run the change of getting lost in details. In our experiment the teachers did not have any experience with the 4C-ID methodology and might not have been able to distinguish between relevant information and details. In future research it would be interesting to use filtered process-oriented worked examples that only contain relevant information.

Finally, two other explanations are related to the medium used for the process-based worked examples. In the Process-WE condition the learner has to process and remember linear presented (video) information, without the possibility to go back in the materials, imposing an extra cognitive load. Secondly, Salomon (1981, 1984), has stated that the depth of mental elaboration depends on the type of medium. In his view, written or 'digitally' displayed information has a potential to deeper mental elaboration than similar 'analogous' or linear displayed information via radio, television or video. According to Salomon verbally or graphically presented materials also have a higher 'status' for the learner as learning materials than materials representing familiar live situations such as displayed by television.

Although, in general, the Product-WE condition was superior to the

Process-WE condition, the participants of the latter condition indicated to have more confidence in the 4C-ID methodology as a possible solution to design problems in their educational institutes. A possible explanation of this discrepancy is the fact that the observation of a successful attempt of an expert designing a training in the Process-WE condition inspires more confidence than the study of a written product-oriented WE in the Product-WE condition by themselves. In addition, the participants in the Process-WE condition heard how and why certain design steps need to be taken, which might have increased their confidence. These observations suggest that for training in the 4C-ID methodology to be effective in terms of design skill and confidence about the methodology, it should start with product-based WEs and end with process-based WEs. In future research it would be interesting to investigate the effects of this mixed training strategy.
In summary, although process-oriented worked examples can be argued to represent a promising way of training teachers to design competency-based education, this exploratory study showed that product-oriented worked examples are a more effective means for training teachers for this task than process-oriented worked examples. However, training with video-based process-oriented worked examples seems to add to the teacher's confidence about the applicability of the design method. Consequently, a mixed strategy, consisting of product-oriented and process-oriented WEs, seems a promising way to support higher-education teachers in their struggle to become instructional designers of competency-based education.

References

Achtenhagen, F. (2001). Criteria for the development of complex teaching-learning environments. *Instructional Science, 29,* 361-381.

Arguelles, A., & Gonczi, A. E. (2000). *Competency based education and training: a world perspective*. Mexico City: Grupo Noriega Editores.

Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning form examples: Instructional principles from the worked examples research. *Review of Educational Research, 70,* 181-214.

Bandura, A. (1986). *Social foundations of thought and actions: A social cognitive theory.* Englewood Cliffs, N.J.: Prentice Hall.

Braaksma, M. A. H., Rijlaarsdam, G., & van den Bergh, H. (2002). Observational learning and the effects of model-observer similarity. *Journal of Educational Psychology, 94,* 405-415.

Clark, R. E., & Estes, F. (1999). The development of authentic educational technologies. *Educational Technology, 39*(2), 5-16.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In Resnick, L. B. (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc,

Enkenberg, J. (2001). Instructional design and emerging teaching models in higher education. *Computers in Human Behavior, 17*, 495-506.

Hoogveld, A. W. M., Paas, F., & Jochems, W. M. G. (In press). Application of an instructional systems design approach by teachers in higher education: individual versus team design. *Teaching and Teacher Education*.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merrienboer, J. J. G. (2001). The effects of a Web-based training in an instructional systems design approach on teachers' instructional design behavior. *Computers in Human Behavior, 17,* 363-371.

Hoogveld, A. W. M., Paas, F., Jochems, W. M. G., & Van Merrienboer, J. J. G. (2002b). Exploring teachers' instructional design practices from a systems design perspective. *Instructional Science, 30,* 291-305.

Janssen-Noordman, A. M. B., & van Merriënboer, J. J. G. (2002). *Innovatief onderwijs ontwerpen. Via leertaken naar complexe vaardigheden.* [Designing innovative education: from learning tasks to complex skills]. Groningen, The Netherlands: Wolters-Noordhoff.

Jentsch, F., Bowers, C., & Salas, E. (2001). What determines whether observers recognize targeted behaviors in modeling displays? *Human Factors, 43,* 496-507.

Keen, K. (1992). Competence: What is it and how can it be developed? In J. Lowyck, P. De Potter & J. Elen (Eds.), *Instructional Design: Implementation issues* (pp. 111-122). Brussels: IBM International Education Center.

Kerr, S. T. (1996). Visions of sugarplums: The future of technology, education and the schools. In S.T. Kerr (Ed.), *Ninety-fifth yearbook of the National Society for the Study of Education: Part II. Technology and the future of schooling* (pp. 1-27). Chicago: National Society for the Study of Education.

Klauer, K. J. (1997). Instructional design theory: A field in the making. In R.D. Tennyson, F. Schott, N. Seel & S. Dijkstra (Eds.), *Instructional design: International perspectives. Volume 1* (pp. 447-455). Mahwah, N J: London.

Levesque, K., Lauen, D., Teitelbaum, P. A. M., Librera, S., & M. P. R. Associates, Inc. (2000). *Vocational education in the United States: Toward the year 2000* (Report Nr. 029). Washington D.C.: U.S. Department of Education. Office of Educational Research and Improvement.

Moallem, M. (1998). An expert teacher's thinking and teaching and instructional design models and principles: an ethnographic study. *Educational Technology Research and Development. 46*, 37-64.

Paas, F., Tuovinen, J., Tabbers, H., & Van Gerven, P.W.M. (2002). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist. 38,* 63-71.

Pratt, D. and Associates. (1998). *Five perspectives on teaching in adult and higher education*. Malabar, Florida: Krieger Publishing Company.

Salomon, G. (1981). *Interaction of media, cognition and learning* (1th ed.). San Francisco, Washington, London: Jossey-Bass.

Salomon, G. (1984). Television is 'easy' and print is 'tough': The differential investment of mental effort in learning as a function of perceptions and attributions. *Journal of Business and Technical Communication 76,* 647-658.

Samuelowicz, K. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41,* 299-325.

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: uses in assessing rater reliability. *Psychological Bulletin 86*(2)*,* 420-428.

Spector, M. J. (2001). Philosophical implications for the design of instruction. *Instructional Science, 29*, 381-403.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*, 257-285.

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10,* 251-295.

Tennyson, R. D. (2001). Defining core competencies of an instructional technologist. *Computers in Human Behavior, 17*, 355-361.

Van Merriënboer, J. J. G. (1997). *Training complex cognitieve skills: A four component instructional design model for technical training.* Englewood Cliffs, N.J.: Educational Technology Publications.

Van Merriënboer, J. J. G., Clark, R. E., & de Croock, M. B. M. (2002). Blueprints for complex learning: the 4C-ID model. *Educational Technology Research and Development, 50,* 50-64.

Van Merriënboer, J. J. G., & de Croock, M. B. M. (2002). Performance-based ISD: 10 steps to complex learning. *Performance Improvement, 41,* 33-39.

Van Merriënboer, J. J. G., & Kirschner, P. A. (2001). Three worlds of instructional design: state of the art and future directions. *Instructional Science, 29,* 429-441.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction, 9,* 257-280.

Chapter 6

Concluding remarks and future research

In this thesis an attempt was made to explore the nature and the causes (Chapter 2), and possible solutions of the instructional design problems that higher-education teachers experience as a result of the recent curricular changes in higher education (Chapters 3, 4, and 5). The new curriculum focuses on competency-based educational principles instead of traditional knowledge-oriented educational principles. Consequently, teachers are required to adopt the new roles of 'coach' of the learning process and, particularly, of 'instructional designer' of study units for competency-based education (CBE). The new role of instructional designer implies that teachers need to be able to translate abstract principles of newly revised curriculum frameworks for CBE into concrete learning experiences in the form of authentic tasks. This focus of CBE on authentic 'whole' learning tasks as the driving force of learning was identified as the teachers' main design challenge of the transition process from knowledge-based to competency-based higher education. The holistic character of CBE adds a lot of complexity to the teacher's instructional design task of integrating theory and practice through problem solving in real world contexts and whole tasks. Also, it forces them to widen their scope from the lesson level to the curriculum level. This means that they have to see the domain as a unified whole and to understand the coordination and integration of its constituent skills. It was assumed that Instructional Systems Design (ISD) approaches could effectively support the instructional design process of teachers in the new curriculum. In particular, the four-component instructional design (4C-ID) methodology of Van Merriënboer (1997) was considered suitable, because it takes 'whole' professional tasks as the starting point, it is learning-process oriented, and is relatively non-prescriptive.

To verify the assumptions about the teachers' problems with the new competency-based curriculum, in Chapter 2, the teacher's actual experience-based or intuitive instructional design approach was explored and it was determined, to what extent it corresponds to an Instructional Systems Design (ISD) approach. In Chapter 3, it was investigated whether a web-based training in the 4C-ID approach can compensate for the deficiencies that were identified in the teachers' intuitive instructional design approach in Chapter 2. The question whether such the 4C-ID approach can best be applied by individual teachers or in small teams of teachers, was answered in Chapter 4. Finally, in order to optimize the training of teachers, Chapter 5 describes an exploratory study in which the conventional training of the 4C-ID approach with product-oriented worked examples was compared to an alternative approach focusing on process-oriented worked examples. This Chapter, in order, describes the main results, conclusions and discussion of the four experimental studies, and ideas for future research.

Main results, conclusions and discussion

The exploration of the teacher's instructional design approach and its comparison to a general ISD approach in Chapter 2, revealed deficiencies in the instructional design skill with regard to two phases. Teachers paid relatively little attention to the instructional design phases of problem analysis and evaluation. This finding was highly compatible with the relatively low recognition of the two corresponding innovative teacher roles of 'diagnostician' and 'evaluator'.

In Chapter 3, the comparison of web-based training of the 4C-ID methodology to a training aimed at optimizing the experience-based, intuitive instructional design approach showed that the 4C-ID training resulted in higher design quality and was rated more positively by the teachers than the experience-based approach.

Chapter 4 describes the differential effects of teachers' individual and collaborative performance on the application of the 4C-ID approach. After higher- education teachers were trained in an ISD approach they had to apply the approach both individually and as a member of a design team. The main hypothesis that the resulting collaborative designs would be better than individual designs was confirmed for low individual achievers but not for high individual achievers. In addition, a negative relationship between the attitude towards the ISD approach and the attitude towards collaborative design was found.

The main goal of the study described in Chapter 5 was to optimize the training of the 4C-ID approach. This exploratory study compared an experimental condition with process-oriented worked examples to the conventional training condition with emphasis on product-oriented worked examples. The results of the application of the 4C-ID approach to two design problems revealed that the quality of the resulting design materials was higher in the product-oriented worked examples condition than in the process-oriented worked examples condition.

From the results of the four studies described in this thesis, it can be concluded that higher-education teachers involved in curriculum redesign for CBE, can be substantially supported by equipping them with the appropriate instructional design skills. This can be realized by training in an Instructional Systems Design approach. The 4C-ID approach of Van Merriënboer was identified as suitable methodology. In comparison with the experience-based, intuitive instructional design approach, it provides a better solution to the problems that higher-education teachers experience in their confrontation with the demands of competency-based education. An additional way to deal with the complexity that CBE represents is formed by collaborative design. Collaborative design efforts turned out to be effective, especially for the low individual achieving teachers. Finally, from the results of the fourth study it was concluded that a mixed training strategy, consisting of product-oriented and process-oriented worked examples, seems a promising way to support higher-education teachers in their struggle to become instructional designers of competency-based education.

The intention of the research carried out in the four studies in this thesis was to get more insight in the problems higher-education teachers experience in developing study units or learning tasks for competency-based education and to try to find appropriate solutions for these problems. From all three experimental studies, in which 79 teachers from 18 study profiles from 21 different Dutch institutes of higher education participated, it can concluded that teachers were generally positive about the trained ISD methodology for design of CBE. This conclusion is not consistent to what was found in literature, namely that teachers are generally not very interested in ISD approaches. It was argued that the character of the design problems of higher-education teachers, the integrative design of learning experiences to acquire a competence, justified the application of ISD methods and more specifically the 4C-ID method.

In general the participating teachers seem to be supported by the training in ISD methodology. However these results should be taken with some caution. Research in this field of curriculum innovation and teacher empowerment is complex. For example, there is an important dilemma with regard to its ecological validity and the level of experimental control. Two of the presented studies in this thesis were carried out in a laboratory context and were well controlled. The study, which was conducted in a more ecologically valid, but less controlled environment (see Chapter 3) suffered from high dropout. Further, a factor that might have contributed to the high drop out is motivation. Whereas the teachers in the ecologically valid environment were mainly extrinsically motivated to participate in the training by their school administrators, the participants in the controlled experiments were mainly recruited and intrinsically motivated by personal networks. This motivational difference might have contributed to the different drop out rates. Nevertheless, it can be argued that gain in experimental control can only be attained at the cost of ecological validity. At the same time, this line of reasoning makes clear that more experiments need to be conducted before practical recommendations can be generated. The results of the studies in this thesis can be viewed as first step in trying to apply instructional design theories more directly in complex innovations and curriculum design processes. We hope that the results from these studies will trigger new, more ecologically valid research projects that, in addition, focus on the organizational context teachers have to work in, i.e. the coordination of the curriculum redesign processes, such as CBE. Only then it will be possible to generate practical recommendations for the teacher's new role as designer of competency-based education. Both practitioners and researchers should keep in mind that the training of practicing teachers to design CBE is important to close the acute gap that exists between the institutional wish to implement a CBE concept and the teachers' inability to realize this as a result of the lack of appropriate learning materials. However, it is even more important to start with the implementation of the ideas of CBE into the curriculum of institutes for teacher training. In the long term, this is probably the only way to prepare future teachers for the role of instructional designer that is indissolubly connected to CBE.

Suggestions for future research

Follow-up research in curriculum projects is needed to assess the long-term effects of the training. Can they still remember and apply the method, do they still use it, have they informed their management or other colleagues about it, and what are their wishes regarding follow-up on the training? It is assumed that the effects of a short training, like the training used in the studies of this thesis, will fade over time. Future research about the potential of the 4C-ID methodology, the long-term effects of training, the need for consultancy and so on, can shed light on these questions. Other important questions for future research have to do with the *duration and the type* of the training. With regard to duration, it is clear that a training of a complex methodology, such as the 4C-ID, cannot be trained and mastered in four (see Chapter 5) to twenty hours (see Chapter 3). For a training to be effective we expect duration of at least a few days. In practice we have seen that a training of four days is convenient for teachers. However, some empirical validation is needed. With regard to the type of training, only one exploratory study was reported in this thesis. A suggestion for an alternative type of training was done in Chapter 5, where it was concluded that a mixed training strategy, consisting of product-oriented and process-oriented worked-out examples, product-oriented for beginning teacher-as-designers, and process-oriented in later stages of expertise, seems a promising way to support higher-education teachers.

The role of *collaboration in the design process* represents another issue for future research. In the study presented in Chapter 4, small design teams of two or three teachers had to work on design tasks. Important questions relate to the variables of team size and team roles, related to curriculum development for CBE.

A related promising approach to the training and adoption of an instructional design approach is the use of *design partnerships*, which can consist of teachers, students, and instructional designers. We expect that involving several stakeholders that are able to contribute to the instructional design process can create a strong basis for the instructional design approach.

Another interesting point to be studied in future research has to do with the restricted focus of the thesis on higher-education teachers. It is clear that the teacher is just one aspect of a system, which also consists of students, the school, the organization, and so on. We believe that training and convincing the teachers is very important, but without organizational support, not sufficient to guarantee that an instructional systems design approach is accepted as a solution to the problems that teachers experience. New studies could focus on the *role of the management* of institutes of higher education for the adoption of the proposed instructional design approach.

The problems with competency-based approaches to education are not exclusive for the Dutch field of higher education. On an international level the problems are recognized in most Western countries. On a national level, the problem is also recognized in other types of education, such as secondary vocational education. The *generalizability* of the presented instructional design solution to *other countries* and *other types of education* remains to be studied.

Summary

The recent curriculum reform in higher education is characterized by a transition of teaching concepts from knowledge oriented to competency based. Competency-based education (CBE) is aimed at providing students with the knowledge, skills and attitudes that enable them to recognize and solve problems in their domain of study and future work. This educational format requires students to take more responsibility for their own learning process, which is initiated by competency-based learning tasks. The successful realization of CBE heavily depends on the teachers' contribution to the curriculum reform. Teachers involved in the implementation of the new competency-based curriculum have to widen their scope from the lesson level to the level of curriculum development in their institutes, and they have to adopt the new role of coach of the students' learning processes and let go of their traditional role of knowledge transmitter, and they are expected to translate the new abstract curriculum framework in their institutes into concrete study units and learning tasks by adopting the new role of instructional designer. As such, for the teachers, the core processes associated with the curricular innovation process can be considered to relate to the process of instructional design. Teachers are reported to experience problems in realizing this translation process. Most importantly, they are not equipped with the appropriate instructional design skills. An important characteristic of CBE, which adds a lot of complexity to the teachers' design task, is its focus on authentic whole tasks. This means that the teachers have to be able to see the domain system as a unified whole and to think in terms of highly integrated sets of learning goals. It is assumed that the teachers' intuitive design approaches are not suited to design learning tasks for the competency-based curriculum. In this thesis,

the teachers' acquisition of expertise in Instructional Systems Design (ISD) is considered a potential solution to the problems that they experience.

An ISD model and methodology that could contribute to solve the teachers' translation problems is the Four Component Instructional Design (4C-ID) model of van Merriënboer (1997). This model was especially developed for the design of learning tasks for complex cognitive skills or competencies. It is learning-process oriented and its relatively non-prescriptive character makes it acceptable to teachers. The 4C-ID method is expected to enable teachers to design a training of the competence, which enables the student to practice the whole task in the same form, as competent practitioners in the domain would normally have to carry out. In this thesis it is researched if training higher-education teachers - involved in learning task development for competency based education - in the 4C-ID methodology will improve their design performance and if so, under which conditions the methodology is most effective. Two conditions are considered in the research, the influence of collaborative design efforts, which is inspired by the ongoing practice in the educational institutes, and the influence of different training strategies. Preliminary to the research an exploration is carried out to describe teachers' current design practices for study units and compare this with a typical ISD approach.
In the exploratory study described in Chapter 2, a Repertory Grid technique was used to analyze experience-based design activities of ten higher-education teachers. Their actual approach was compared with an instructional systems design (ISD) approach and related to innovative teacher roles. Teachers' activities show an imbalance in two ID phases, that is problem analysis and evaluation. The results suggest that they attempt to translate curricular goals directly into concrete lessons, without an appropriate problem analysis, and that they pay relatively little attention to evaluation. In line with this finding, the teachers underrate the two innovative teacher roles of the 'diagnostician' and the 'evaluator'. It is argued that imbalanced or incomplete design approaches and perceived roles may hinder innovation in education. Implications for the support of teachers' design activities are discussed.

Chapter 3 reports about an investigation into the effects of an Instructional Systems Design (ISD) training on teachers' instructional design behavior. Thirty-six teachers from 16 Dutch Teacher Training Colleges received 20 hours of web-based training either in an ISD based condition or in an experience-based design condition (EXP). In the ISD condition teachers were trained to apply the 4C-ID model of van Merriënboer (1997), in the EXP condition the teachers were trained to optimize their own approach. The results supported the hypotheses, indicating that the ISD-based training resulted in a higher quality of design and was evaluated more positive than the EXP approach. These findings suggest that training in an ISD approach can effectively support teachers' instructional design strategies.

Chapter 4 reports about a study into the differential effects of teachers' individual and collaborative performance on the application of an Instructional Systems Design (ISD) approach. Forty-two higher-education teachers were trained in an ISD approach and subsequently had to apply the approach both individually and as a member of a design team. The main hypothesis that the resulting collaborative designs would be better than individual designs was not confirmed. However, a detailed analysis of the results revealed that low individual achievers could profit from the collaborative design efforts, whereas the high individual achievers could not. In addition, a negative relationship between attitude towards the ISD approach and the attitude towards collaborative design was found. The implications of these results for a new role of the teacher as a designer are discussed.

Chapter 5 describes an experiment in which the conventional training of the 4C-ID approach was compared to an alternative approach. The studies described in the Chapters 3 and 4 have shown that teachers who were trained to apply an instructional systems design methodology were able to design better learning tasks for CBE than teachers who designed the learning tasks with their experienced-based design method. In order to optimize the training, this study compared an experimental condition with process-oriented worked examples to a conventional training condition with emphasis on product-oriented worked examples. After the training,

the participants - 25 higher-education teachers - had to apply the ISD methodology to two design problems. The quality of the resulting design materials, as rated by experts, was higher in the product-oriented worked examples condition than in the process-oriented worked examples condition. The significance of this finding for the training approach for design methodology for CBE is discussed.
In Chapter 6 conclusions and a discussion on the basis of the overall results are presented. Training higher-education teachers to use an ISD method can be seen as a first step in solving the problems that they experience with translating competency-based curriculum principles into concrete learning tasks. The results show that this training should preferably consist of product-based worked examples. In addition, the design of learning tasks seems to be more effective by small teams of teachers. Finally, several important questions for future research are presented.

Samenvatting (Summary in Dutch)

De recente vernieuwingen in het curriculum van opleidingen voor hoger onderwijs worden gekenmerkt door een accentverschuiving van een op kennis gericht naar een op competenties gericht onderwijsconcept. Competentiegericht onderwijs richt zich erop studenten toe te rusten met de kennis, vaardigheden en attitudes die het hun mogelijk maken, de problemen op het terrein van hun vakgebied en toekomstige werk te herkennen en op te lossen. In deze onderwijsvorm wordt van studenten verwacht dat zij meer verantwoordelijkheid nemen voor hun eigen leerproces, hetgeen geïnitieerd kan worden door competentiegerichte leertaken. Het met succes realiseren van competentiegericht onderwijs hangt sterk af van de bijdrage van leraren aan de curriculumvernieuwing. Leraren die in hun instelling betrokken zijn bij de implementatie van een vernieuwd, competentiegericht curriculum moeten hun takenpakket verbreden van lesgeven naar curriculumvernieuwing in hun instelling. Ze moeten de nieuwe rol aannemen van leerprocesbegeleider van hun studenten, minder nadruk leggen op de klassieke rol van overdrager van kennis en van hen wordt verwacht dat ze in de rol van instructieontwerper de abstracte principes van het vernieuwde curriculum van hun instelling vertalen in concrete modulen en leertaken. Daarom kan gezegd worden dat de belangrijkste processen bij curriculumvernieuwing beschouwd kunnen worden als een vorm van onderwijskundig ontwerpen. Leraren, zo blijkt uit visitatierapporten, ondervinden problemen bij dit vertaalproces. Een belangrijke constatering is daarbij dat zij niet over de vaardigheden beschikken die nodig zijn om onderwijs mee te kunnen ontwerpen. Een onderscheidend kenmerk van competentiegericht onderwijs, dat de ontwerptaak van de leraar nog compliceert, is dat in deze onderwijsvorm

de authenticiteit en gerichtheid op de hele taak zo centraal staan. Dat betekent dat de leraren in staat moeten zijn om het totaal aan taken in een competentiedomein als een ondeelbaar geheel te zien en te denken in leerdoelen die tezamen de integrale competentie vormen. Aangenomen wordt dat de intuïtieve ontwerpaanpak van leraren niet is toegesneden op het ontwerpen van leertaken voor een competentie gericht curriculum. In dit proefschrift wordt er vanuit gegaan dat het opdoen van ervaring door de leraren in een onderwijskundige systeembenadering (Instructional Systems Design of ISD) een mogelijke bijdrage kan vormen voor de oplossing van hun ontwerpproblemen.
Het Four Component Instructional Design (4C-ID) model (van Merriënboer 1997) kan beschouwd worden als een bruikbaar ontwerpmodel om de vertaalproblemen waar de leraren mee kampen te helpen oplossen. Dit model werd met name ontwikkeld om leertaken voor complexe cognitieve vaardigheden, of competenties mee te kunnen ontwerpen. Het model is gericht op leerprocessen en het relatief weinig prescriptieve karakter van het model maakt het voor leraren makkelijker acceptabel om mee te werken. De verwachting is dat leraren door gebruik van de 4C-ID methode in staat zijn om het aanleren van de competentie zo te ontwerpen dat de student de gelegenheid krijgt om de hele taak op dezelfde wijze te oefenen die door een ervaren beroepsbeoefenaar wordt toegepast. In dit proefschrift is onderzocht of het trainen van docenten uit het hoger onderwijs, die leertaken moeten ontwikkelen voor competentiegericht onderwijs, in de 4C-ID methodologie hun ontwerpprestaties kan verbeteren en onder welke condities de methodologie het meest effectief is. Er werden twee condities onderzocht, de invloed van samenwerking door leraren tijdens het ontwerp, gebaseerde op de gebruikelijke praktijk in de onderwijsinstellingen en de invloed van verschil in trainingsaanpak. Voorafgaand aan het onderzoek werd een verkennend onderzoek uitgevoerd om de gangbare praktijk van leraren bij het ontwerpen van modulen in kaart te brengen en deze te vergelijken met een prototypische ISD-aanpak.
In het exploratieve onderzoek, beschreven in Hoofdstuk 2, werd een

Repertory Grid techniek gebruikt om de huidige ontwerpaanpak van tien leraren te analyseren. Deze aanpak werd vergeleken met een aanpak volgens de onderwijskundige systeembenadering (ISD-benadering) en in verband gebracht met vernieuwende rollen van leraren. De activiteiten van de leraren laten een onevenwichtigheid zien in twee fases van onderwijsontwerp, namelijk de probleemanalyse en de evaluatie. Uit de resultaten kan worden begrepen dat ze de curriculumdoelstellingen direct in concrete lessen proberen te vertalen en dat ze tevens relatief weinig aandacht besteden aan evaluatie. Overeenkomend met deze bevinding is dat de leraren laag scoren op de twee vernieuwende rollen voor de leraar, de 'leraar als diagnosticus' en de 'leraar als evaluator'. Er wordt gesteld dat onevenwichtige of onvolledige ontwerpbenaderingen en de rolopvatting de onderwijsvernieuwing belemmeren. De betekenis van ondersteuning van leraren bij hun ontwerpactiviteiten wordt bediscussieerd.

In Hoofdstuk 3 wordt een onderzoek gerapporteerd naar de effecten van een training in ontwerpen volgens een onderwijskundige systeembenadering (Instructional Systems Design, ISD). Zesendertig lerarenopleiders uit 16 Pabo's kregen een 20 uur durende training op internet, ofwel in een ISD conditie ofwel in een op ervaring gebaseerde (ERV) conditie. In de ISD conditie werden de leraren getraind in het toepassen van de 4C-ID methode (van Merriënboer, 1997) en in de ERV conditie werden ze getraind om de eigen, op ervaring gebaseerde aanpak, te optimaliseren. De resultaten stemden overeen met de hypothese dat de training in de ISD conditie in betere ontwerpen en een positievere evaluatie van de aanpak zal resulteren dan de ERV gebaseerde aanpak. Uit deze bevindingen kan worden geconcludeerd dat een training in een ISD-benadering de ontwerpaanpak van leraren effectief kan ondersteunen.

In Hoofdstuk 4 wordt gerapporteerd over een onderzoek naar de verschillende effecten van een individuele dan wel een team ontwerpaanpak met een ISD methode. Tweeënveertig docenten uit het hoger onderwijs werden getraind in een ISD ontwerpmethode en moesten vervolgens deze aanpak zowel individueel als in de rol van lid van een ontwerpteam toepassen. De hypothese dat de resulterende teamontwerpen beter zouden zijn dan de individuele, kon niet worden bevestigd. Uit een verdere analyse van de resultaten op deelniveau kon geconstateerd worden dat de docenten die individueel laag presteerden het beter deden tijdens de teamontwerpopdracht, terwijl dit niet opging voor de docenten die individueel hoog presteerden. De betekenis van deze uitkomsten voor de nieuwe rol van de leraar als ontwerper werd besproken.

In Hoofdstuk 5 wordt een experiment beschreven waarin de gebruikelijke trainingsopzet voor de 4C-ID methode werd vergeleken met een alternatieve aanpak. De onderzoeken uit de Hoofdstukken 3 en 4 lieten zien dat leraren die getraind werden in het toepassen van een ISD methodologie in staat waren betere leertaken te ontwerpen voor competentiegericht onderwijs dan leraren die hun op eigen ervaring gebaseerde werkwijze toepasten. Om deze training te kunnen verbeteren werd in dit onderzoek een experimentele conditie met procesgerichte uitgewerkte voorbeelden vergeleken met een conventionele trainingsconditie met productgerichte uitgewerkte voorbeelden. Na de training moesten de – 25 docenten hoger onderwijs – de ISD-methodologie toepassen op twee ontwerpproblemen. De kwaliteit van de resulterende ontwerpmaterialen, als beoordeeld door experts, was in de conditie van de productgerichte uitgewerkte voorbeelden hoger dan die in de conditie van de procesgerichte uitgewerkte voorbeelden. De betekenis van deze uitkomst voor de opzet van de training in de 4C-ID ontwerpmethodologie werd besproken.

In Hoofdstuk 6 zijn de conclusies en een discussie over het geheel gepresenteerd. Het trainen van docenten in het hoger onderwijs in het toepassen van een ISD ontwerpaanpak kan beschouwd worden als een eerste stap in het oplossen van de problemen die deze docenten ondervinden bij het vertalen van de principes van een op competentiegericht onderwijs gebaseerd curriculum in concrete leertaken. De resultaten laten zien dat deze training het beste kan bestaan uit productgerichte uitgewerkte voorbeelden. Bovendien lijkt de training effectiever als de leraren in kleine teams ontwerpen. Tenslotte worden belangrijke vragen voor verder onderzoek geformuleerd.

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Curriculum Vitae

Albertus (Bert) Wilhelmus Marie Hoogveld was born on April 2, 1949 in Bunde, the Netherlands. He attended secondary school (Gymnasium β) at the Henric van Veldeke College in Maastricht from 1961 to 1968. After secondary school Hoogveld studied chemistry at the Groningen State University, from 1968 to 1971 and educational technology at the same university, from 1971 to 1980. He graduated in 1980 as a Master in pedagogy with as specialization educational technology and minor study musicology.

From 1972 to 1973 Bert Hoogveld was secretary of the credit-point synchronization committee in the Social Faculty of the Groningen State University, and from 1974 to 1978 he was as assistant manager responsible for the educational technology training in the same university's teacher training institute.

From 1979 to 1982 he was founder and manager of the Audiovisual Centre of the seven Deventer Higher Professional Education Institutes.

From 1982 to 1984, Bert Hoogveld was curriculum developer at the National Institute for Curriculum Development (Stichting voor de Leerplan Ontwikkeling, SLO in Enschede, the Netherlands), department of art education and in a project curriculum development for cultural education, and wrote a curriculum format for cultural education for the national common curriculum.

From 1984 to 1985 he was founder and first manager of the audiovisual centre of the national agricultural educational service center (Audiovisueel Centrum STOAS) in Wageningen, the Netherlands.

From 1985 to 1986 Bert Hoogveld was teacher in instructional theory and practice in the teacher training institute for nursing in Leusden, the

Netherlands. He redesigned and taught study units in instructional science From 1986 till now Bert Hoogveld is educational technologist at the Educational expertise center (Otec) of the Open Universiteit Nederland. As experienced instructional designer he is responsible for many course designs, project manager of many (multi)media-projects. In 1993 he was awarded with the Sony Interactive Video Award for the interactive practical: Assessment Centre. His recent work covers design and realization of web based competency-based curricula and research in instructional design for competency-based education.